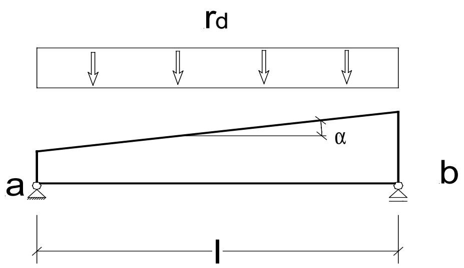
Euro-Code 5

Beams

Half-span roof:



System:

Beam length l =	7,00 m
Beam width b =	14,00 cm
Beam height an a h_a =	26,00 cm
Pitch α =	6,00 °
Support length t =	10,00 cm

Materials:

Construction material CM=	SEL("wood/kmod"; CM;)	=	Glulam
Class of load duration CLD=	SEL("wood/kmod"; CLD;)	=	short term
Utility class UC=	SEL("wood/kmod"; UC;)	=	1
$\Rightarrow k_{mod}$ =	TAB("wood/kmod"; kmod; CM=CM; CLD=CLD; UC=UC)	=	0,90
Strength grade SG=	SEL("wood/EC"; SG;)	=	BS14h
$f_{m,g,k}$ =	TAB("wood/EC"; fm.k; SG=SG)	=	28,00 N/mm²
$f_{v,g,k}$ =	TAB("wood/EC"; fv.k; SG=SG)	=	2,70 N/mm²
$f_{t,90,g,k}$ =	TAB("wood/EC"; ft,90.k; SG=SG)	=	0,45 N/mm²
$f_{c,90,k}$ =	TAB("wood/EC"; fc,90.k; SG=SG)	=	5,50 N/mm²
$E_{0,mean}$ =	TAB("wood/EC"; E0.mean; SG=SG)	=	12500,00 N/mm²
γ_M =	1,30		
γ_S =	1,10		

Load:

r_d = 12,50 kN/m

Calculation:

$f_{m,g,d}$ =	$f_{m,g,k} * k_{mod} / \gamma_M$	=	19,38 N/mm²
$f_{v,g,d}$ =	$f_{v,g,k} * k_{mod} / \gamma_M$	=	1,87 N/mm²
$f_{c,90,d}$ =	$f_{c,90,k} * k_{mod} / \gamma_M$	=	3,81 N/mm²
$f_{t,90,g,d}$ =	$f_{t,90,g,k} * k_{mod} / \gamma_M$	=	0,31 N/mm²

Stress resultants for analysis of load bearing capacity:

M_d =	$r_d * l^2 / 8$	=	76,56 kNm
V_d =	$l / 2 * r_d$	=	43,75 kN
$h_{s,req}$ =	$150*V_d/(b*f_{v,g,d})$	=	250,67 mm
$h_{s,req} / (10*h_a)$		=	**0,96 < 1**
h_b =	h_a+l*100*TAN(α)	=	99,57 cm

Point of maximum stress:

x =	$l/(1+h_b/h_a)$	=	1,45 m
$M_{x,d}$ =	$V_d * x - r_d * x^2 * 0,5$	=	50,30 kNm
$W_{x,req}$ =	$1100 * M_{x,d} / f_{m,g,d}$	=	2855,01 cm³
h_x =	$h_a+x*100*TAN(\alpha)$	=	41,24 cm
W_x =	$b * h_x^2 / 6$	=	3968,39 cm³
$W_{x,req} / W_x$		=	**0,72 < 1**

Required area moment of second degree at a deflection of l/300:

I_{req} =	$3130000 * M_d / 1,4 * l / E_{0,mean}$	=	95853,12 cm4
$h_{m,req}$ =	$0,1*(12000*I_{req}/b)^{1/3}$	=	43,47 cm
h_m =	$(h_b-h_a)/2+h_a$	=	62,78 cm
$h_{m,req} / h_m$		=	**0,69 < 1**

Analysis of load-bearing capacity:

Shearing stress at footing a:

$\tau_{a,d}$ =	$1,5*V_d*10/(b*h_a)$	=	1,80 N/cm²
$\tau_{a,d} / f_{v,g,d}$		=	**0,96 < 1**

Stresses in the edge parallel to the grain:

$\sigma_{m,0,d}$ =	$0,001*(1+4*(TAN(\alpha))^2)*6*10^6*M_{x,d}/(b*h_x^2)$	=	13,24 N/mm²
$\sigma_{m,0,d} / f_{m,g,d}$		=	**0,68 < 1**

Stresses in the edge with grains at an angle:

$\sigma_{m,\alpha,d}$ =	$0,001*(1-4*(TAN(\alpha))^2)*6*10^6*M_{x,d}/(b*h_x^2)$	=	12,12 N/mm²
$f_{m,\alpha,d}$ =	$f_{m,g,d}/(f_{m,g,d}/f_{c,90,d}*(SIN(\alpha))^2+(COS(\alpha))^2)$	=	18,55 N/mm²
$\sigma_{m,\alpha,d} / f_{m,\alpha,d}$		=	**0,65 < 1**

Bearing pressure:

Assumption: l < 150 mm;l_1 > 150 mm ; $k_{c,90}$ according to Tab. 5.1.5

$\Rightarrow k_{c,90}$ = 1,0

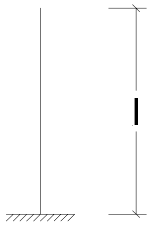
req_A =	$V_d *10 / (f_{c,90,d} * k_{c,90})$	=	114,83 cm²
req_t =	req_A / b	=	8,20 cm
req_t / t		=	**0,82 < 1**

Buck

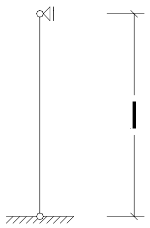
Buckling lengths:

Euler's crippling load:

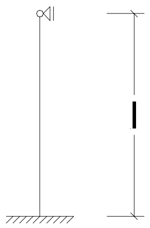
l = 5,00 m



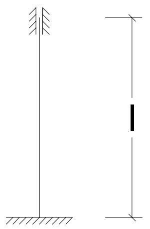
l_{ef} = 2*l = 10,00 m



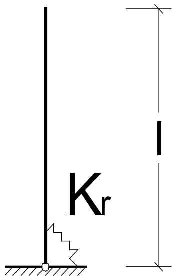
l_{ef} = l = 5,00 m



l_{ef} = 0,7*l = 3,50 m

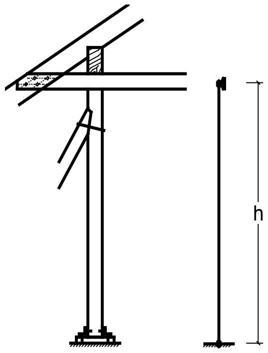


l_{ef} = 0,5*l = 2,50 m



Sorting grade SG =	SEL("Wood/EC"; SG;)	=	S10
$E_{0,mean}$ =	TAB("Wood/EC"; $E_{0.mean}$; SG=SG)	=	11000,00 N/mm²
K_r =			100000,00 1/N
l_{ef} =	$l*\sqrt{(4+(\pi^2*E_{0,mean})/(l*K_r))}$	=	10,27 m

Roof post:



System:

Post height h =	3,40 m
Cross-sectional width b =	14,00 cm
Cross-sectional thickness d =	14,00 cm

Materials:

Construction material CM=	SEL("wood/kmod"; CM;)	=	solid wood
Class of load duration CLD=	SEL("wood/kmod"; CLD;)	=	short term
Utility class UC=	SEL("wood/kmod"; UC;)	=	2
⇒ k_{mod} =	TAB("wood/kmod"; kmod; CM=CM; CLD=CLD; UC=UC)	=	0,90

Strength grade SG=	SEL("wood/EC"; SG;)	=	S10
ρ_k =	TAB("wood/EC"; ρk; SG=SG)	=	380,00 kg/m³
$f_{c,0,k}$ =	TAB("wood/EC"; fc,0,k; SG=SG)	=	21,00 N/mm²
$f_{c,90,k}$ =	TAB("wood/EC"; fc,90,k; SG=SG)	=	5,00 N/mm²
γ_M =	1,30		

Load at the head:

$V_{c,d}$ = 50,40 kN

Calculation:

Buckling length l_{ef} =	h	=	3,40 m
A =	b *d	=	196,00 cm²
i =	1/√(12)*MIN(b;d)	=	4,04 cm
Degree of slenderness λ_{min} =	100*l_{ef}/i	=	84,16 > 30

⇒ Buckling proof required!

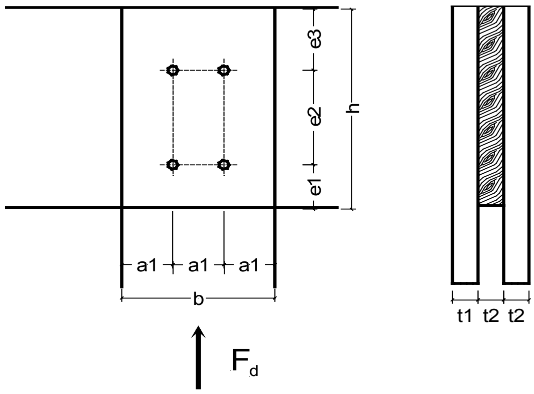
k_c =	TAB("wood/ECbuckl"; kc; SG=SG; $\lambda=\lambda_{min}$)	=	0,427
$\sigma_{c,0,d}$ =	10*$V_{c,d}$ / A	=	2,57 N/mm²
$f_{c,0,d}$ =	$f_{c,0,k}$ * k_{mod}/γ_M	=	14,54 N/mm²
$f_{c,90,d}$ =	$f_{c,90,k}$ * k_{mod}/γ_M	=	3,46 N/mm²

Structural verifications:

Buckling:	$\sigma_{c,0,d}$ /(k_c*$f_{c,0,d}$)	=	**0,41 < 1**
Lateral pressure:	$\sigma_{c,0,d}$/$f_{c,90,d}$	=	**0,74 < 1**

Dowel

Beam connection:



System:

Distance a_1 =			4,00 cm
Width b =	$3*a_1$	=	12,00 cm
Distance e_1 =			4,00 cm
Distance e_2 =			8,50 cm
Distance e_3 =			5,50 cm
Thickness t_1=			6,00 cm
Thickness t_2 =			8,00 cm

Load:

F_d = 40,00 kN

Material:

Construction material CM=	SEL("wood/kmod"; CM;)	=	solid wood
Class of load duration CLD=	SEL("wood/kmod"; CLD;)	=	normal
Utility class UC=	SEL("wood/kmod"; UC;)	=	1
⇒ k_{mod} =	TAB("wood/kmod"; kmod; CM=CM; CLD=CLD; UC=UC)	=	0,80

Strength grade SG=	SEL("wood/EC"; SG;)	=	S10
ρ_k =	TAB("wood/EC"; ρk; SG=SG)	=	380,00 kg/m³
γ_M =	1,30		

Dowel: S235

Dowel diameter d =	SEL("wood/DPin"; d;)/10	=	1,20 cm
$f_{u,k}$ =	360,00 N/mm²		
γ_S =	1,10 N/mm²		

Calculation:

$M_{y,d}$ = $0.8*f_{u,k}*d^3/(6*\gamma_S)*10^3$ = 75403,64 Nmm

Post:

$f_{h,1,d}$ = $0.082 * \rho_k * (1-0.1*d)*k_{mod}/\gamma_M$ = 16,87 N/mm²

Support:

k_{90} = 1.35 + 0.15 * d = 1,53

$f_{h,2,d}$ = $0.082 * \rho_k * (1-0.1*d)*k_{mod}/(\gamma_M*k_{90})$ = 11,03 N/mm²

β = $f_{h,2,d} / f_{h,1,d}$ = 0,654

R_{D1} = $f_{h,1,d} * t_1 * d * 100$ =12146 N

R_{D2} = $0.5 * f_{h,1,d} * t_2 * d * \beta * 100$ =5296 N

R_{D3} = $1,1*f_{h,1,d}*10^2*t_1*d/(2+\beta)*(\sqrt{(2*\beta*(1+\beta)+4*\beta*(2+\beta)*M_{y,d}/(f_{h,1,d}*10^3*d*t_1^2))}-\beta)$ =5254 N

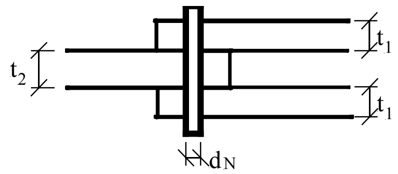
R_{D4} = $1.1*\sqrt{(2*\beta/(1+\beta))}*\sqrt{(2*M_{y,d}*f_{h,1,d}*d*10)}$ =5405 N

R_D = $0.001 * MIN(R_{D1};R_{D2};R_{D3};R_{D4})$ = **5,25 kN**

n = $F_d / (2 * R_D)$ = **3,8**

selected: 4 PIN ∅ 12mm S 235 l = 20 cm

Tensile splice Design of strut



System:

Timber thickness t_1 = 8,00 cm

Timber thickness t_2 = 12,00 cm

Load:

F_{sd} = 116,00 kN

Materials: NH S 10

Construction material CM= SEL("wood/kmod"; CM;) = solid wood

Class of load duration CLD= SEL("wood/kmod"; CLD;) = normal

Utility class UC= SEL("wood/kmod"; UC;) = 2

⇒ k_{mod} = TAB("wood/kmod"; kmod; CM=CM; CLD=CLD; UC=UC) = 0,80

Strength grade SG= SEL("wood/EC"; SG;) = S10

ρ_k = TAB("wood/EC"; ρk; SG=SG) = 380,00 kg/m³

γ_M = 1,30

γ_S = 1,10

Dowel: DPin ∅ 16mm S 275

Dowel diameter d = SEL("wood/DPin"; d;)/10 = 0,80 cm

$f_{u,k}$ = 360,00 N/mm²

Calculation:

Minimum distances according to Tab.6.6a:

a_1 = 7* d = 5,60 cm

a_2 = 3 * d = 2,40 cm

$a_{3,t}$ = 7* d = 5,60 cm

$a_{4,t}$ = 3 * d = 2,40 cm

Design value of bearing stress resistance:

$f_{h,0,d}$ = 0.082 * ρ_k * (1-0.1*d)*k_{mod}/γ_M = 17,64 N/mm²

$M_{y,d}$ = 1000*0.8*$f_{u,k}$*d³/(6*γ_S) = 22341,82 Nmm

k_M = 10*t_1 / √($M_{y,d}$ / ($f_{h,0,d}$ * d *10)) = 6,36

R_{D1} = 100* $f_{h,0,d}$ * t_1 * d = 11289,60 N

R_{D2} = 100* 0.5 * $f_{h,0,d}$ * t_2 * d = 8467,20 N

R_{D3} = 100* 0.367 * $f_{h,0,d}$ * t_1 * d * (2 * √(1 + 3 / k_M²) - 1) = 4445,08 N

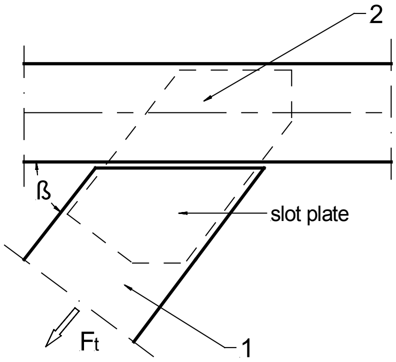
R_{D4} = 155.6 * $f_{h,0,d}$ * t_1 * d / k_M = 2762,05 N

R_D = 0.001 * MIN(R_{D1};R_{D2};R_{D3};R_{D4}) = **2,76 kN**

required number of dowels n = $F_{sd}/(2*R_D)$ = **21,0**

selected: 6 dowels ∅ 16 S235 l=28cm

Tension diagonal:



System:

Rod 1 : **1 * 160mm * 160mm Glulam**
Rod 2 : **1 * 160mm * 180mm Glulam**

System angle β =	60,0 °
Timber thickness t_1 =	16,00 cm
Timber thickness t_2 =	16,00 cm
Thickness of slotted plate t_3 =	0,80 cm

Construction material CM=	SEL("wood/kmod"; CM;)	=	Glulam
Class of load duration CLD=	SEL("wood/kmod"; CLD;)	=	normal
Utility class UC=	SEL("wood/kmod"; UC;)	=	2
$\Rightarrow k_{mod}$ =	TAB("wood/kmod"; kmod; CM=CM; CLD=CLD; UC=UC)	=	0,80

Strength grade SG=	SEL("wood/EC"; SG;)	=	BS11
ρ_k =	TAB("wood/EC"; ρk; SG=SG)	=	410,00 kg/m³
γ_M =	1,30		
γ_S =	1,10		

Dowel: DPin ∅ 16mm S 275

Dowel diameter d =	SEL("wood/DPin"; d;)/10	=	1,60 cm
$f_{u,k}$ =	430,00 N/mm²		

$F_{t,d}$ = 80,79 kN

Calculation:

Minimum distances of Rod1 according to Tab.6.6a:

a_1 =	7* d	=	11,20 cm
a_2 =	3 * d	=	4,80 cm
$a_{3,t}$ =	7* d	=	11,20 cm
$a_{4,t}$ =	3 * d	=	4,80 cm

Minimum distances Rod2 according to Tab.6.6a:

a_1 =	(3 + 4 * ABS(COS(β)))* d	=	8,00 cm
a_2 =	3 * d	=	4,80 cm
$a_{3,t}$ continuous top chord			
$a_{4,t}$ =	(2 + 2 * ABS(SIN(β))) * d	=	5,97 cm

Rod 1 :

$f_{h,1,d}$ = 0.082 * ρ_k * (1-0.1*d)*k_{mod} /γ_M = 17,38 N/mm²

Rod 2 :

$f_{h,0.d}$ = 0.082 * ρ_k * (1-0.1*d)*k_{mod} /γ_M = 17,38 N/mm²

k_{90} = 1.35 + 0.15 * d = 1,59

$f_{h,2,d}$ = $f_{h,0.d}$ /(k_{90}*(SIN(β))²+(COS(β))²) = 12,05 N/mm²

$M_{y,d}$ = 0.8*$f_{u,k}$*d³*1000/(6*γ_S) = 213488,48 Nmm

Design value of drift pins in Rod 1:

R_{D1} = 100* $f_{h,1,d}$ *(t_1 / 2 - t_3) * d = 20022 N

R_{D2} = 1.1*$f_{h,1,d}$*(10*t_1/2-10*t_3)*d*10*(√(2+4*$M_{y,d}$/($f_{h,1,d}$*10*d*(10*t_1/2-10*t_3)²))-1) =13437 N

R_{D3} = 1.5* √(20*$M_{y,d}$*$f_{h,1,d}$*d) = 16345 N

R_D = 0.001 * MIN(R_{D1};R_{D2};R_{D3}) = **13,44 kN**

n = $F_{t,d}$ / (2 * R_D) = **3,0**

selected: 4 DPin ∅ 16 S 275 l = 16cm

Design value of drift pins in Rod 2:

R_{D1} = 100* $f_{h,2,d}$ *(t_1 / 2 - t_3) * d = 13882 N

R_{D2} = 1.1*$f_{h,2,d}$*(10*t_1/2-10*t_3)*10*d*(√(2+4*$M_{y,d}$/($f_{h,2,d}$*10*d*(10*t_1/2-10*t_3)²))-1) = 10528 N

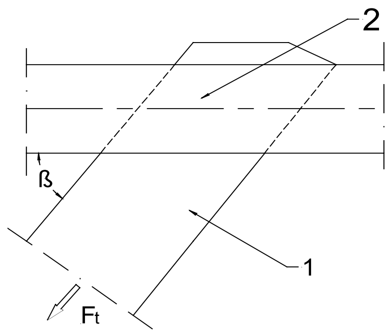
R_{D3} = 15* √(0.2*$M_{y,d}$*$f_{h,2,d}$*d) = 13610 N

R_D = 0.001 * MIN(R_{D1};R_{D2};R_{D3}) = **10,53 kN**

n = $F_{t,d}$ / (2 * R_D) = **3,8**

selected: 4 DPin ∅ 16 S 275 l = 16cm

Tension diagonal:



System:

Rod 1 : 2 * 60mm * 140mm
Rod 2 : 1 * 100mm * 180mm
System angle β = 60,00 °
Timber thickness t_1 = 6,00 cm
Timber thickness t_2 = 10,00 cm

Construction material CM= SEL("wood/kmod"; CM;) = solid wood
Class of load duration CLD= SEL("wood/kmod"; CLD;) = normal
Utility class UC= SEL("wood/kmod"; UC;) = 2
$\Rightarrow k_{mod}$ = TAB("wood/kmod"; kmod; CM=CM; CLD=CLD; UC=UC) = 0,80

Strength grade SG= SEL("wood/EC"; SG;) = S7
ρ_k = TAB("wood/EC"; ρk; SG=SG) = 350,00 kg/m³

γ_M = 1,30
γ_S = 1,10

Dowel: DPin ∅ 12mm

Dowel diameter d = SEL("wood/DPin"; d;)/10 = 1,20 cm
$f_{u,k}$ = 360,00 N/mm²

Load:

$F_{t,d}$ = 40,00 kN

Calculation:

Minimum distances of Rod1 according to Tab.6.6a:

a_1 = 7* d = 8,40 cm
a_2 = 3 * d = 3,60 cm
$a_{3,t}$ = 7* d = 8,40 cm
$a_{4,t}$ = 3 * d = 3,60 cm

Minimum distances Rod2 according to Tab.6.6a:

a_1 = (3 + 4 * ABS(COS(β)))* d = 6,00 cm
a_2 = 3 * d = 3,60 cm
$a_{3,t}$ continuous top chord
$a_{4,t}$ = (2 + 2 * ABS(SIN(β))) * d = 4,48 cm

Rod 1 :

$f_{h,1,d}$ = 0.082 * ρ_k * (1-0.1*d)*k_{mod}/γ_M = 15,54 N/mm²

Rod 2 :

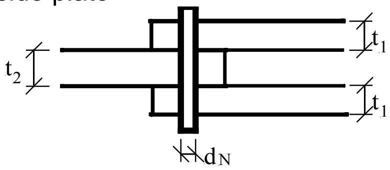
$f_{h,0.d}$ =	0.082 * ρ_k * (1-0.1*d)*k_{mod}/γ_M	=	15,54 N/mm²
k_{90} =	1.35 + 0.15 * d	=	1,53
$f_{h,2,d}$ =	$f_{h,0.d}/(k_{90}$*(SIN(β))²+(COS(β))²)	=	11,12 N/mm²
β =	$f_{h,2,d}$ / $f_{h,1,d}$	=	0,716
$M_{y,d}$ =	10 ^{3}*0.8*$f_{u,k}$*d³/(6* γ_S)	=	75403,64 Nmm
R_{D1} =	100* $f_{h,1,d}$ * t_1 * d	=	11189 N
R_{D2} =	100* 0.5 * $f_{h,1,d}$ * t_2 * d * β	=	6676 N
R_{D3} =	1.1*$f_{h,1,d}$*t_1*100*d/(2+β)*(√(2*β *(1+β)+4*β*(2+β)*$M_{y,d}$/($f_{h,1,d}$*10^3*d*$t_1$²))-β)	=	5026 N
R_{D4} =	1.1* √(2*β/(1+β))*√(2*$M_{y,d}$ *$f_{h,1,d}$*10*d)	=	5329 N
R_D =	0.001 * MIN(R_{D1};R_{D2};R_{D3};R_{D4})	=	**5,03 kN**
n =	$F_{t,d}$ / (2 * R_D)	=	**4,0**

selected: 4 DPin ∅ 12 S 235 l = 22cm

Nail

Nail calculation for each shear joint, thin outside plate:

Thin outside plate



System:

Sheet thickness t_1 = 0,15 cm

Timber thickness t_2 = 4,00 cm

Materials:

Construction material CM= SEL("wood/kmod"; CM;) = solid wood

Class of load duration CLD= SEL("wood/kmod"; CLD;) = short term

Utility class UC= SEL("wood/kmod"; UC;) = 1

$\Rightarrow k_{mod}$ = TAB("wood/kmod"; kmod; CM=CM; CLD=CLD; UC=UC) = 0,90

Strength grade SG= SEL("wood/EC"; SG;) = S13

ρ_k = TAB("wood/EC"; ρk; SG=SG) = 380,00 kg/m³

γ_M = 1,30

γ_S = 1,10

Nails: 38x100

Nail length l_N = 10,00 cm

Nail diameter d_N = 0,38 cm

t_1 / d_N = 0,39 < 0,5

otherwise a different calculation applies

Calculation:

pre-drilled:

$f_{h,k}$ = $0.082 * \rho_k * (1-0.1*d_N)$ = 29,98 N/mm²

not pre-drilled::

$f_{h,k}$ = $0.082 * \rho_k * (10*d_N)^{-0.3}$ = 20,88 N/mm²

Characteristic value for yield moment of square nails

$M_{y,d}$ = $270 * (10*d_N)^{2.6} / \gamma_S$ = 7896,02 Nmm

Characteristic value for yield moment of round nails

$M_{y,d}$ = $180 * (10*d_N)^{2.6} / \gamma_S$ = 5264,02 Nmm

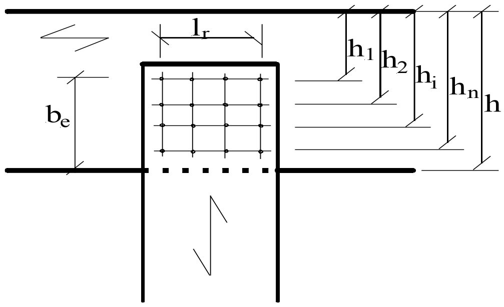
$f_{h,d}$ = $k_{mod} / \gamma_M * f_{h,k}$ = 14,46 N/mm²

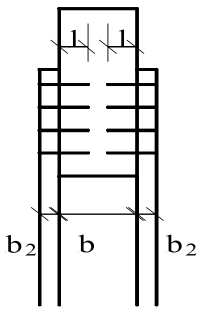
R_{D1} = $100*0.5* f_{h,d} * t_2 * d_N$ = 1098,96 N

R_{D2} = $1.1*\sqrt{(20*M_{y,d}*f_{h,d}*d_N)}$ = 836,65 N

R_D = $0.001 * MIN(R_{D1};R_{D2})$ = **0,84 kN**

Design of a shear connection:





System:

Thickness of outer wood d_2 = 4,00 cm
Nail distance l_r = 6,00 cm
Nail distance b_e = 16,00 cm
Cross beam width b = 16,00 cm
Cross beam height h = 40,00 cm
Height h_1= 24,00 cm
Height h_2 = 28,00 cm
Height h_3 = 32,00 cm
Height h_4 = 36,00 cm

Materials:

Construction material CM= SEL("wood/kmod"; CM;) = Glulam
Class of load duration CLD= SEL("wood/kmod"; CLD;) = short term
Utility class UC= SEL("wood/kmod"; UC;) = 1
⇒ k_{mod} = TAB("wood/kmod"; kmod; CM=CM; CLD=CLD; UC=UC) = 0,90
Strength grade SG= SEL("wood/EC"; SG;) = BS11
Shear and torsion $f_{v,g,k}$ = TAB("wood/EC"; fv,k; SG=SG) = 2,70 N/mm²
Rectangular shear $f_{t,90,g,k}$ = TAB("wood/EC"; ft,90.k; SG=SG) = 0,45 N/mm²
γ_{MH} = 1,30

Strength grade SG= SEL("wood/EC"; SG;) = S10
Rectangular shear $f_{t,0,k}$ = TAB("wood/EC"; ft,0,k; SG=SG) = 14,00 N/mm²

Nails 38x100:
Nail diameter d = 0,38 cm
Nail length l_N = 10,00 cm
Nail strength R_D = 6000*d² = 866,40 N

γ_F = 1,50

$f_{v,g,d}$ = k_{mod}*$f_{v,g,k}$/ γ_{MH} = 1,869 N/mm²
$f_{t,90,g,d}$ = k_{mod}*$f_{t,90,g,k}$/ γ_{MH} = 0,312 N/mm²
$f_{t,0,d}$ = k_{mod}*$f_{t,0,k}$/γ_{MH} = 9,692 N/mm²
l_{eff} = 10*MIN(d_2;12*d;l_N-d_2) = 40,00 mm

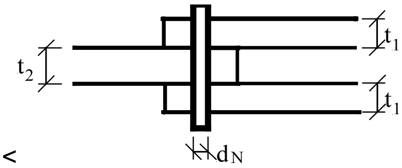
Calculation of maximum design value:
from nail analysis $F_{90,d,N}$ = 0.002 * 16 * R_D = 27,72 kN
from tension bar $F_{90,d,Z}$ = 0.2 / γ_F * d_2 *l_N * $f_{t,0,d}$ = 51,69 kN

detailed structural verification:

b_e / h		=	0,40 < 0,5
⇒ detailed structural verification required			
b_{ef} =	$2 * l_{eff}$	=	80,00 mm
c =	$4/3 *\sqrt{(b_e/h * (1 - b_e/h)^3)}$	=	0,392
$l_{r,ef}$ =	$10*\sqrt{(l_r^2 + (c * h)^2)}$	=	167,89 mm
A_{ef} =	$l_{r,ef} * b_{ef}$	=	13431,20 mm²
k_r =	$0.25 *((1) + (h_1 /h_2)^2 + (h_1 /h_3)^2 + (h_1 /h_4)^2)$	=	0,685
η =	$1 - 3 * (b_e/h)^2 + 2 * (b_e/h)^3$	=	0,648
$F_{90,d}$ =	$0.001 / (\eta * k_r) * 13 * A_{ef}^{0.8} * f_{t,90,g,d}$	=	18,34 kN
Decisive $F_{90,d,max}$ =	$MIN(F_{90,d};F_{90,d,N};F_{90,d,Z})$	=	**18,34 kN**

Nail calculation for each shear joint for two different kinds of wood:

two unequal kinds of wood



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System:

Timber thickness t_1 = 4,00 cm

Timber thickness t_2 = 4,00 cm

$t_1 \leq t_2$

Materials:

Construction material CM=	SEL("wood/kmod"; CM;)	=	solid wood
Class of load duration CLD=	SEL("wood/kmod"; CLD;)	=	short term
Utility class UC=	SEL("wood/kmod"; UC;)	=	1
$\Rightarrow k_{mod}$ =	TAB("wood/kmod"; kmod; CM=CM; CLD=CLD; UC=UC)	=	0,90
Strength grade SG1=	SEL("wood/EC"; SG;)	=	S13
ρ_{k1} =	TAB("wood/EC"; ρk; SG=SG1)	=	380,00 kg/m³
Strength grade SG2=	SEL("wood/EC"; SG;)	=	MS13
ρ_{k2} =	TAB("wood/EC"; ρk; SG=SG2)	=	400,00 kg/m³

γ_M = 1,30

γ_S = 1,10

Nails: 38x100

Nail length l_N = 10,00 cm

Nail diameter d_N = 0,38 cm

Calculation:

pre-drilled:

$f_{h,k1}$ = 0.082 * ρ_{k1} * (1-0.1*d_N) = 29,98 N/mm²

not pre-drilled::

$f_{h,k1}$ = 0.082 * ρ_{k1} * $(10*d_N)^{-0.3}$ = 20,88 N/mm²

pre-drilled:

$f_{h,k2}$ = 0.082 * ρ_{k2} * (1-0.1*d_N) = 31,55 N/mm²

not pre-drilled::

$f_{h,k2}$ = 0.082 * ρ_{k2} * $(10*d_N)^{-0.3}$ = 21,98 N/mm²

Characteristic value for yield moment of square nails

$M_{y,d}$ = 270 * $(10*d_N)^{2.6}$ / γ_S = 7896,02 Nmm

Characteristic value for yield moment of round nails

$M_{y,d}$ = 180 * $(10*d_N)^{2.6}$ / γ_S = 5264,02 Nmm

$f_{h,d1}$ = k_{mod} / γ_M * $f_{h,k1}$ = 14,46 N/mm²

$f_{h,d2}$ = k_{mod} / γ_M * $f_{h,k2}$ = 15,22 N/mm²

β = $f_{h,d1}$ / $f_{h,d2}$ = 0,95

R_{D1} = 100* $f_{h,d1}$ * t_1 * d_N = 2197,92 N

R_{D2} = 100* 0.5 * $f_{h,d1}$ * t_2 * d_N * β = 1044,01 N

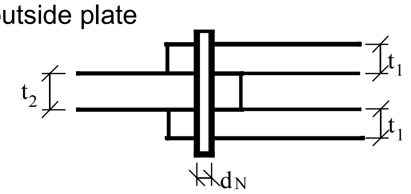
R_{D3} = 110*$f_{h,d1}$*t_1*d_N /(2+β)*(√(2*β*(1+β)+4* β*(2+β)*$M_{y,d}$/($f_{h,d1}$*10^3*d_N*t_1 ²))-β) = 935,89 N

R_{D4} = 1.1*√(2*β/(1+β))* √(20*$M_{y,d}$*$f_{h,d1}$*d_N) = 825,85 N

R_D = 0.001 * MIN(R_{D1};R_{D2};R_{D3};R_{D4}) = <u>**0,83 kN**</u>

Nail calculation for each shear joint:

Thick outside plate



System:

Sheet thickness t_1 = 0,50 cm

Timber thickness t_2 = 4,00 cm

Materials:

Construction material CM= SEL("wood/kmod"; CM;) = solid wood

Class of load duration CLD= SEL("wood/kmod"; CLD;) = short term

Utility class UC= SEL("wood/kmod"; UC;) = 1

$\Rightarrow k_{mod}$ = TAB("wood/kmod"; kmod; CM=CM; CLD=CLD; UC=UC) = 0,90

Strength grade SG= SEL("wood/EC"; SG;) = S13

ρ_k = TAB("wood/EC"; ρk; SG=SG) = 380,00 kg/m³

γ_M = 1,30

γ_S = 1,10

Nails: 38x100

Nail length l_N = 10,00 cm

Nail diameter d_N = 0,38 cm

otherwise a different calculation applies

Calculation:

pre-drilled:

$f_{h,k}$ = 0.082 * ρ_k * (1-0.1*d_N) = 29,98 N/mm²

not pre-drilled::

$f_{h,k}$ = 0.082 * ρ_k * $(10 \cdot d_N)^{-0.3}$ = 20,88 N/mm²

Characteristic value for yield moment of square nails

$M_{y,d}$ = 270 * $(10 \cdot d_N)^{2.6} / \gamma_S$ = 7896,02 Nmm

Characteristic value for yield moment of round nails

$M_{y,d}$ = 180 * $(10 \cdot d_N)^{2.6} / \gamma_S$ = 5264,02 Nmm

$f_{h,d}$ = $k_{mod} / \gamma_M \cdot f_{h,k}$ = 14,46 N/mm²

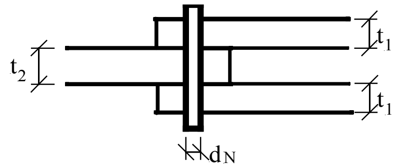
R_{D1} = 100*0.5* $f_{h,d}$ * t_2 * d_N = 1098,96 N

R_{D2} = 1.5*$\sqrt{(20 \cdot M_{y,d} \cdot f_{h,d} \cdot d_N)}$ = 1140,88 N

R_D = 0.001 * MIN(R_{D1};R_{D2}) = **1,10 kN**

Nail calculation for each shear joint, plate inside:

Plate inside



System:

Timber thickness t_1 = 4,00 cm
Sheet thickness t_2 = 1,00 cm

Materials:

Construction material CM= SEL("wood/kmod"; CM;) = solid wood
Class of load duration CLD= SEL("wood/kmod"; CLD;) = short term
Utility class UC= SEL("wood/kmod"; UC;) = 1
⇒ k_{mod} = TAB("wood/kmod"; kmod; CM=CM; CLD=CLD; UC=UC) = 0,90
Strength grade SG= SEL("wood/EC"; SG;) = S13
ρ_k = TAB("wood/EC"; ρk; SG=SG) = 380,00 kg/m³
γ_M = 1,30
γ_S = 1,10

Nails: 38x100

Nail length l_N = 10,00 cm
Nail diameter d_N = 0,38 cm

Calculation:

pre-drilled:
$f_{h,k}$ = $0.082 * \rho_k * (1\text{-}0.1*d_N)$ = 29,98 N/mm²
not pre-drilled::
$f_{h,k}$ = $0.082 * \rho_k * (10*d_N)^{-0.3}$ = 20,88 N/mm²

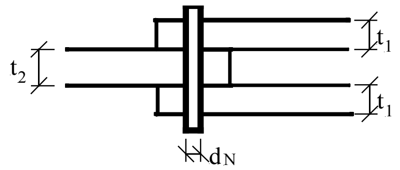
Characteristic value for yield moment of square nails
$M_{y,d}$ = $270 * (10*d_N)^{2.6} / \gamma_S$ = 7896,02 Nmm
Characteristic value for yield moment of round nails
$M_{y,d}$ = $180 * (10*d_N)^{2.6} / \gamma_S$ = 5264,02 Nmm

$f_{h,d}$ = $k_{mod} / \gamma_M * f_{h,k}$ = 14,46 N/mm²

R_{D1} = $100 * f_{h,d} * t_1 * d_N$ = 2197,92 N
R_{D2} = $110*f_{h,d}*t_1*d_N*(\sqrt{(2+4*M_{y,d}/(f_{h,d}*10^3*d_N*t_1^2))}-1)$ = 1200,38 N
R_{D3} = $1.5*\sqrt{(20*M_{y,d}*f_{h,d}*d_N)}$ = 1140,88 N

R_D = $0.001 * MIN(R_{D1};R_{D2};R_{D3})$ = **1,14 kN**

Nail calculation for each shear joint:



System:

Timber thickness t_1 = 4,00 cm

Timber thickness t_2 = 4,00 cm

Materials:

Construction material CM= SEL("wood/kmod"; CM;) = solid wood

Class of load duration CLD= SEL("wood/kmod"; CLD;) = short term

Utility class UC= SEL("wood/kmod"; UC;) = 1

$\Rightarrow k_{mod}$ = TAB("wood/kmod"; kmod; CM=CM; CLD=CLD; UC=UC) = 0,90

Strength grade SG= SEL("wood/EC"; SG;) = S13

ρ_k = TAB("wood/EC"; ρk; SG=SG) = 380,00 kg/m³

γ_M = 1,30

γ_S = 1,10

Nails: 38x100

Nail length l_N = 10,00 cm

Nail diameter d_N = 0,38 cm

Calculation:

pre-drilled:

$f_{h,k}$ = 0.082 * ρ_k * (1-0.1*d_N) = 29,98 N/mm²

not pre-drilled::

$f_{h,k}$ = 0.082 * ρ_k * $(10*d_N)^{-0.3}$ = 20,88 N/mm²

Characteristic value for yield moment of square nails

$M_{y,d}$ = 270 * $(10*d_N)^{2.6}$ / γ_S = 7896,02 Nmm

Characteristic value for yield moment of round nails

$M_{y,d}$ = 180 * $(10*d_N)^{2.6}$ / γ_S = 5264,02 Nmm

$f_{h,d}$ = k_{mod} / γ_M * $f_{h,k}$ = 14,46 N/mm²

k_M = 10*MIN(t_1;t_2) / √($M_{y,d}$ / ($f_{h,d}$ *10* d_N)) = 4,09

R_{D1} = 100* $f_{h,d}$ * t_1 * d_N = 2197,92 N

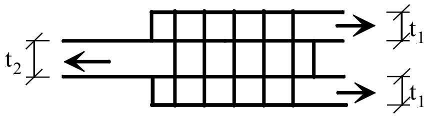
R_{D2} = 100* 0.5 * $f_{h,d}$ * t_2 * d_N = 1098,96 N

R_{D3} = 100*0.367*$f_{h,d}$ *t_1*d_N*(2*√(1+3/k_M²)-1) = 945,34 N

R_{D4} = 155.6 * $f_{h,d}$ * t_1 * d_N / k_M = 836,18 N

R_D = 0.001 * MIN(R_{D1};R_{D2};R_{D3};R_{D4}) = **0,84 kN**

Determination of required number of nails



System:

Timber thickness t_1 =	4,00 cm	
Timber thickness t_2 =	4,00 cm	

Materials:

Construction material CM =	SEL("wood/kmod"; CM;)	=	solid wood
Class of load duration CLD =	SEL("wood/kmod"; CLD;)	=	permanent
Utility class UC=	SEL("wood/kmod"; UC;)	=	2
$\Rightarrow k_{mod}$ =	TAB("wood/kmod"; kmod; CM=CM; CLD=CLD; UC=UC)	=	0,60
Strength grade SG=	SEL("wood/EC"; SG;)	=	S10
ρ_k =	TAB("wood/EC"; ρk; SG=SG)	=	380,00 kg/m³
γ_M =	1,30		
γ_S =	1,10		

Nails: 42x110

Nail length l_N =	12,00 cm	
Nail diameter d_N =	0,42 cm	

Load:

F_{sd} = 16,00 kN

Calculation:

Minimum timber thickness adhered to according to 6.3.1.2(11):

$(MAX(7*d_N;(13*d_N -30)*\rho_k/400))/(MIN(t_1;t_2))$ = 0,73 < 1

Minimum driving depth according to 6.3.1.2(4):

$(8*d_N)/MIN(t_1;t_2)$ = 0,84 < 1

Minimum nail distances according to Tab.6.3.1.2:

a_1 =	$10* d_N$	=	4,20 cm
a_2 =	$5 * d_N$	=	2,10 cm
$a_{3,t}$ =	$15* d_N$	=	6,30 cm
$a_{4,t}$ =	$5 * d_N$	=	2,10 cm

pre-drilled $f_{h,k}$ =	$0.082 * \rho_k * (1-0.1*d_N)$	=	29,85 N/mm²
not pre-drilled $f_{h,k}$ =	$0.082 * \rho_k * (10*d_N)^{-0.3}$	=	20,26 N/mm²
$f_{h,d}$ =	$k_{mod} / \gamma_M * f_{h,k}$	=	9,35 N/mm²

Characteristic value for yield moment of square nails

$M_{y,d}$ = $270 * (10*d_N)^{2.6} / \gamma_S$ = 10242,81 Nmm

Characteristic value for yield moment of round nails

$M_{y,d}$ = $180 * (10*d_N)^{2.6} / \gamma_S$ = 6828,54 Nmm

k_M = $10*MIN(t_1 ;t_2) / \sqrt{(M_{y,d} / (f_{h,d} *10* d_N))}$ = 3,03

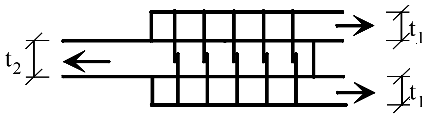
R_{D1} =	$100 * f_{h,d} * t_1 * d_N$	=	1570,80 N
R_{D2} =	$100 * 0.5 * f_{h,d} * t_2 * d_N$	=	785,40 N
R_{D3} =	$36.7 * f_{h,d} * t_1 * d_N * (2 * \sqrt{(1 + 3 / k_M{}^2)} - 1)$	=	751,57 N
R_{D4} =	$155.6 * f_{h,d} * t_1 * d_N / k_M$	=	806,66 N

R_D = $0.001 * MIN(R_{D1} ;R_{D2};R_{D3};R_{D4})$ = **0,75 kN**

required number of nails n = $F_{sd}/(2*R_D)$ = **10,7**

selected: 2x6 nails 42x120 DIN 1151

Determination of required number of nails



System:

Timber thickness t_1 = 4,00 cm
Timber thickness t_2 = 4,00 cm
Timber width b = 8,00 cm

Materials:

Construction material CM = SEL("wood/kmod"; CM;) = solid wood
Class of load duration CLD = SEL("wood/kmod"; CLD;) = permanent
Utility class UC= SEL("wood/kmod"; UC;) = 2
$\Rightarrow k_{mod}$ = TAB("wood/kmod"; kmod; CM=CM; CLD=CLD; UC=UC) = 0,60
Strength grade SG= SEL("wood/EC"; SG;) = S10
ρ_k = TAB("wood/EC"; ρk; SG=SG) = 380,00 kg/m³
γ_M = 1,30
γ_S = 1,10

Nails: 42x110

Nail length l_N = 6,50 cm
Nail diameter d_N = 0,28 cm

Load:

F_{sd} = 16,00 kN

Calculation:

t_3 = $(l_N - t_1)$ = 2,50 cm

Checking the lapped joint length according to 6.3.1.2(10):

$4 * d_N / (t_2 - t_3)$ = 0,75 < 1

Minimum timber thickness adhered to according to 6.3.1.2(11):

$(MAX(7*d_N;(13*d_N-30)*\rho_k/400))/(MIN(t_1;t_2))$ = 0,49 < 1

Minimum driving depth according to 6.3.1.2(4):

$(8*d_N)/MIN(t_1;t_2;t_3)$ = 0,90 < 1

Minimum nail distances according to Tab.6.3.1.2:

a_1 = $10* d_N$ = 2,80 cm
a_2 = $5 * d_N$ = 1,40 cm
$a_{3,t}$ = $15* d_N$ = 4,20 cm
$a_{4,t}$ = $5 * d_N$ = 1,40 cm

pre-drilled $f_{h,k}$ = $0.082 * \rho_k * (1-0.1*d_N)$ = 30,29 N/mm²
not pre-drilled $f_{h,k}$ = $0.082 * \rho_k * (10*d_N)^{-0.3}$ = 22,88 N/mm²
$f_{h,d}$ = $k_{mod} / \gamma_M * f_{h,k}$ = 10,56 N/mm²

Characteristic value for yield moment of square nails

$M_{y,d}$ = $270 * (10*d_N)^{2.6} / \gamma_S$ = 3569,29 Nmm

Characteristic value for yield moment of round nails

$M_{y,d}$ = $180 * (10*d_N)^{2.6} / \gamma_S$ = 2379,53 Nmm

k_t = $MAX(t_1;t_2;t_3)/MIN(t_1;t_2;t_3)$ = 1,60
k_M = $10*MIN(t_1;t_2;t_3) / \sqrt{(M_{y,d} / (f_{h,d} * 10*d_N))}$ = 2,79

R_{D1} = 100* $f_{h,d}$ * MIN(t_1;t_2;t_3) * d_N = 739,20 N

R_{D2} = 100*0.5*$f_{h,d}$ *MIN(t_1;t_2;t_3)*d_N*(√(3 * k_t² + 2 * k_t + 3) - k_t -1) = 416,02 N

R_{D3} = 36.7 * $f_{h,d}$ * MIN(t_1;t_2;t_3) * d_N * (2 * √(1 + 3 / k_M²) - 1) = 367,34 N

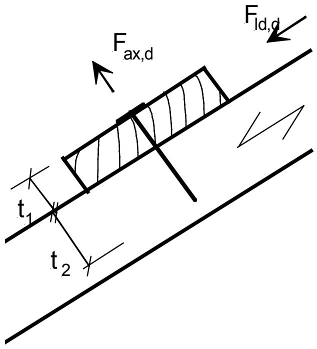
R_{D4} = 155.6 * $f_{h,d}$ * MIN(t_1;t_2;t_3) * d_N / k_M = 412,26 N

R_D = 0.001 * MIN(R_{D1};R_{D2};R_{D3};R_{D4}) = **0,37 kN**

required number of nails n = F_{sd}/R_D = **43,2**

selected: 2x3x8=48 nails 28x65 DIN 1151

Attachment of roof boarding/sheathing



System:

Timber thickness t_1 = 2,80 cm

Materials:

Construction material CM=	SEL("wood/kmod"; CM;)	=	solid wood
Strength grade SG=	SEL("wood/EC"; SG;)	=	S10
ρ_k =	TAB("wood/EC"; ρk; SG=SG)	=	380,00 kg/m³

γ_M = 1,30

γ_S = 1,10

Nails: 38x100

Nail length l_N = 7,50 cm

Nail diameter d_N = 0,40 cm

Load:

Wind suction $F_{ax,d}$ =	0,55 kN CLD: short term
Roof shear Load scheme g $F_{la,d1}$ =	0,25 kN CLD: permanent
Roof shear Load scheme g+s $F_{la,d2}$ =	0,45 kN CLD: short term

Calculation:

Load-bearing capacity under shear load:

pre-drilled $f_{h,k}$ =	$0.082 * \rho_k * (1-0.1*d_N)$	=	29,91 N/mm²
not pre-drilled $f_{h,k}$ =	$0.082 * \rho_k * (10*d_N)^{-0.3}$	=	20,56 N/mm²

Characteristic value for yield moment of square nails

$M_{y,d}$ = $270 * (10*d_N)^{2.6} / \gamma_S$ = 9022,50 Nmm

Characteristic value for yield moment of round nails

$M_{y,d}$ = $180 * (10*d_N)^{2.6} / \gamma_S$ = 6015,00 Nmm

decisive load scheme:

Class of load duration CLD=	SEL("wood/kmod"; CLD;)	=	permanent
Utility class UC=	SEL("wood/kmod"; UC;)	=	2
⇒ k_{mod1} =	TAB("wood/kmod"; kmod; CM=CM; CLD=CLD; UC=UC)	=	0,60
Class of load duration CLD=	SEL("wood/kmod"; CLD;)	=	short term
Utility class UC=	SEL("wood/kmod"; UC;)	=	2
⇒ k_{mod2} =	TAB("wood/kmod"; kmod; CM=CM; CLD=CLD; UC=UC)	=	0,90

$F_{la,d1}*k_{mod2}/(F_{la,d2}*k_{mod1})$ = 0,83 < 1

⇒ Load scheme g+s decisive

$f_{h,d}$ = N/mm²	$k_{mod2} / \gamma_M * f_{h,k}$	=14,23
t_2 =	$(l_N - t_1)$	= 4,70 mm
k_t =	$MAX(t_1;t_2)/MIN(t_1;t_2)$	= 1,68
k_M =	$10*MIN(t_1;t_2) / \sqrt{(M_{y,d} / (f_{h,d} *10* d_N))}$	= 2,72
R_{D1} =	$100* f_{h,d} * t_1 * d_N$	= 1593,76 N
R_{D2} =	$100* 0.5 * f_{h,d} * t_2 * d_N$	= 1337,62 N
R_{D3} =	$100*0.367*f_{h,d} * t_1 * d_N * (2 * \sqrt{(1 + 3 / k_M^2)} - 1)$	= 801,95 N
R_{D4} =	$155.6 * f_{h,d} * t_1 * d_N / k_M$	= 911,72 N
R_D =	$0.001 * MIN(R_{D1} ;R_{D2};R_{D3};R_{D4})$	= **0,80 kN**

$F_{la,d2}/R_D$ = **0,56 < 1**

Pullout capacity:
according to DIN 1052-2 Section 6.3.1

$f_{1,d}$ =	$40*10^{-6}*\rho_k^2*k_{mod2}/\gamma_M$	= 4,00 N/mm²
$f_{2,d}$ = N/mm²	$600*10^{-6} *\rho_k^2*k_{mod2}/\gamma_M$	=59,98
R_{d1} =	$100* f_{1,d} * d_N * t_2$	= 752,00 N
R_{d2} =	$100* f_{2,d} * d_N^2$	= 959,68 N
R_d =	$MIN(R_{d1} ;R_{d2})/1000$	= **0,75 kN**

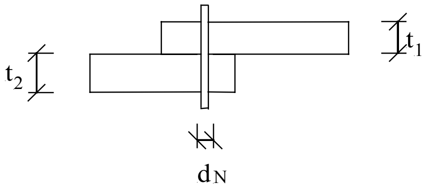
$F_{ax,d}/R_d$ = **0,73 < 1**

Combined loads:

$(F_{ax,d}/R_d)^2+(F_{la,d2}/R_D)^2$ = **0,85 < 1**

Nail calculation for a shear joint (thick plate)

Wood-metal connection with plate $t_1 > 0.5$ d



System:

Sheet thickness t_1 = 0,50 cm
Timber thickness t_2 = 4,00 cm

Materials:

Construction material CM= SEL("wood/kmod"; CM;) = solid wood
Class of load duration CLD= SEL("wood/kmod"; CLD;) = short term
Utility class UC= SEL("wood/kmod"; UC;) = 1
$\Rightarrow k_{mod}$ = TAB("wood/kmod"; kmod; CM=CM; CLD=CLD; UC=UC) = 0,90
Strength grade SG= SEL("wood/EC"; SG;) = S13
ρ_k = TAB("wood/EC"; ρk; SG=SG) = 380,00 kg/m³
γ_M = 1,30
γ_S = 1,10

Nails: 38x100

Nail length l_N = 10,00 cm
Nail diameter d_N = 0,38 cm

Calculation:

pre-drilled:
$f_{h,k}$ = $0.082 * \rho_k * (1-0.1*d_N)$ = 29,98 N/mm²
not pre-drilled::
$f_{h,k}$ = $0.082 * \rho_k * (10*d_N)^{-0.3}$ = 20,88 N/mm²

Characteristic value for yield moment of square nails
$M_{y,d}$ = $270 * (10*d_N)^{2.6} / \gamma_S$ = 7896,02 Nmm
Characteristic value for yield moment of round nails
$M_{y,d}$ = $180 * (10*d_N)^{2.6} / \gamma_S$ = 5264,02 Nmm

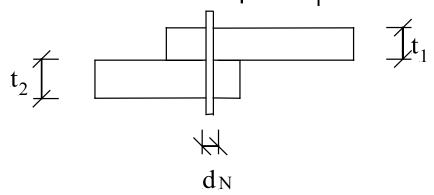
$f_{h,d}$ = $k_{mod} / \gamma_M * f_{h,k}$ = 14,46 N/mm²

R_{D1} = $100*1.1*f_{h,d}*t_2*d_N*(\sqrt{(2+4*M_{y,d}/(f_{h,d}*10^3*d_N*t_2^2))}-1)$ = 1200 N
R_{D2} = $1.5*\sqrt{(20*M_{y,d}*f_{h,d}*d_N)}$ = 1141 N
R_{D3} = $100*f_{h,d}*t_2*d_N$ = 2198 N

R_D = $0.001 * MIN(R_{D1};R_{D2};R_{D3})$ = **1,14 kN**

Nail calculation for a shear joint (thin plate) :

Wood-metal connection with plate t_1 > 0.5 d



System:

Sheet thickness t_1 = 0,15 cm

Timber thickness t_2 = 4,00 cm

Materials:

Construction material CM=	SEL("wood/kmod"; CM;)	=	solid wood
Class of load duration CLD=	SEL("wood/kmod"; CLD;)	=	short term
Utility class UC=	SEL("wood/kmod"; UC;)	=	1
⇒ k_{mod} =	TAB("wood/kmod"; kmod; CM=CM; CLD=CLD; UC=UC)	=	0,90
Strength grade SG=	SEL("wood/EC"; SG;)	=	S13
ρ_k =	TAB("wood/EC"; ρk; SG=SG)	=	380,00 kg/m³

γ_M = 1,30

γ_S = 1,10

Nails: 38x100

Nail length l_N = 10,00 cm

Nail diameter d_N = 0,38 cm

t_1 / d_N = 0,39 < 0,5

otherwise a different calculation applies

Calculation:

pre-drilled:

$f_{h,k}$ = $0.082 * \rho_k * (1-0.1*d_N)$ = 29,98 N/mm²

not pre-drilled::

$f_{h,k}$ = $0.082 * \rho_k * (10*d_N)^{-0.3}$ = 20,88 N/mm²

Characteristic value for yield moment of square nails

$M_{y,d}$ = $270 * (10*d_N)^{2.6} / \gamma_S$ = 7896,02 Nmm

Characteristic value for yield moment of round nails

$M_{y,d}$ = $180 * (10*d_N)^{2.6} / \gamma_S$ = 5264,02 Nmm

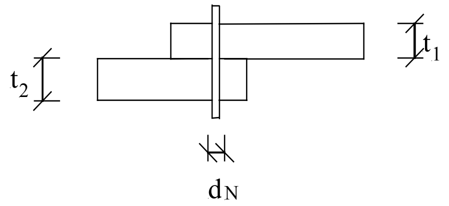
$f_{h,d}$ = $k_{mod} / \gamma_M * f_{h,k}$ = 14,46 N/mm²

R_{D1} = $100* (\sqrt{(2)}-1)*f_{h,d} * t_2 * d_N$ = 910,4 N

R_{D2} = $1.1*\sqrt{(20*M_{y,d}*f_{h,d}*d_N)}$ = 836,6 N

R_D = $0.001 * MIN(R_{D1};R_{D2})$ = **0,84 kN**

Nail calculation for a shear joint:



System:

Timber thickness t_1 =	4,00 cm
Timber thickness t_2 =	4,00 cm

Materials:

Construction material CM=	SEL("wood/kmod"; CM;)	=	solid wood
Class of load duration CLD=	SEL("wood/kmod"; CLD;)	=	short term
Utility class UC=	SEL("wood/kmod"; UC;)	=	1
⇒ k_{mod} =	TAB("wood/kmod"; kmod; CM=CM; CLD=CLD; UC=UC)	=	0,90
Strength grade SG=	SEL("wood/EC"; SG;)	=	S10
ρ_k =	TAB("wood/EC"; ρk; SG=SG)	=	380,00 kg/m³

γ_M = 1,30

γ_S = 1,10

Nails: 38x100

Nail length l_N =	10,00 cm
Nail diameter d_N =	0,38 cm

Calculation:

pre-drilled:

$f_{h,k}$ = $0.08 * \rho_k * (1-0.1*d_N)$ = 29,24 N/mm²

not pre-drilled::

$f_{h,k}$ = $0.082 * \rho_k * (10*d_N)^{-0.3}$ = 20,88 N/mm²

Characteristic value for yield moment of square nails

$M_{y,d}$ = $270 * (10*d_N)^{2.6} / \gamma_S$ = 7896,02 Nmm

Characteristic value for yield moment of round nails

$M_{y,d}$ = $180 * (d_N*10)^{2.6} / \gamma_S$ = 5264,02 Nmm

$f_{h,d}$ = $k_{mod} / \gamma_M * f_{h,k}$ = 14,46 N/mm²

k_t = $MAX(t_1;t_2)/MIN(t_1;t_2)$ = 1,00

k_M = $10*MIN(t_1 ;t_2) / \sqrt{(M_{y,d} / (f_{h,d} *10* d_N))}$ = 4,09

R_{D1} = $100* f_{h,d} * MIN(t_1;t_2) * d_N$ = 2197,92 N

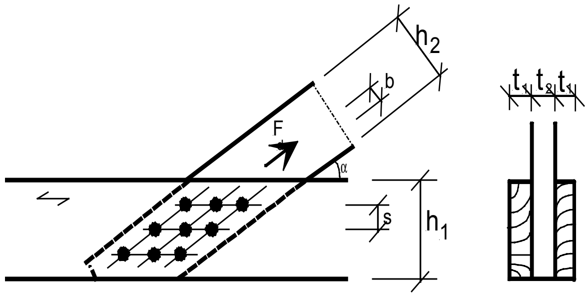
R_{D2} = $100* 0.5*f_{h,d} *MIN(t_1;t_2)*d_N*(\sqrt{(3*k_t^2+2*k_t+3)}-k_t-1)$ = 910,41 N

R_{D3} = $100* 0.367 * f_{h,d} * MIN(t_1;t_2) * d_N * (2 * \sqrt{(1 + 3 / k_M^2)} - 1)$ = 945,34 N

R_{D4} = $100* 1.556 * f_{h,d} * MIN(t_1;t_2) * d_N / k_M$ = 836,18 N

R_D = $0.001 * MIN(R_{D1};R_{D2};R_{D3};R_{D4})$ = **0,84 kN**

Tie rod connection



System:

Timber thickness t_1 =	3,80 cm
Timber thickness t_2 =	3,80 cm
Timber height h_1 =	14,00 cm
Timber height h_2 =	10,00 cm
Nail distance s =	3,50 cm
Nail distance b =	2,50 cm
Nail rows a =	3
Nail columns v =	3

Load:

F_d =	15 kN

Materials:

Construction material CM =	SEL("wood/kmod"; CM;)	=	solid wood
Class of load duration CLD =	SEL("wood/kmod"; CLD;)	=	normal
Utility class UC=	SEL("wood/kmod"; UC;)	=	1
$\Rightarrow k_{mod}$ =	TAB("wood/kmod"; kmod; CM=CM; CLD=CLD; UC=UC)	=	0,80
Strength grade SG=	SEL("wood/EC"; SG;)	=	S10
ρ_k =	TAB("wood/EC"; ρk; SG=SG)	=	380,00 kg/m³
γ_M =	1,30		
γ_S =	1,10		

Nails: 42x110

Nail length l_N =	11,00 cm
Nail diameter d_N =	0,42 cm

Calculation:

$t_3 = (l_N - t_1 - t_2)$ = 3,40 cm

pre-drilled:

$f_{h,k} = 0.082 * \rho_k * (1-0.1*d_N)$ = 29,85 N/mm²

not pre-drilled::Imposed Load:

$f_{h,k} = 0.082 * \rho_k * (10*d_N)^{-0.3}$ = 20,26 N/mm²

Characteristic value for yield moment of square nails

$M_{y,d} = 270 * (10*d_N)^{2.6} / \gamma_S$ = 10242,81 Nmm

Characteristic value for yield moment of round nails

$M_{y,d} = 180 * (10*d_N)^{2.6} / \gamma_S$ = 6828,54 Nmm

$f_{h,d} = k_{mod} / \gamma_M * f_{h,k}$ = 12,47 N/mm²

$k_t = MAX(t_1;t_2)/MIN(t_1;t_2;t_3)$ = 1,12

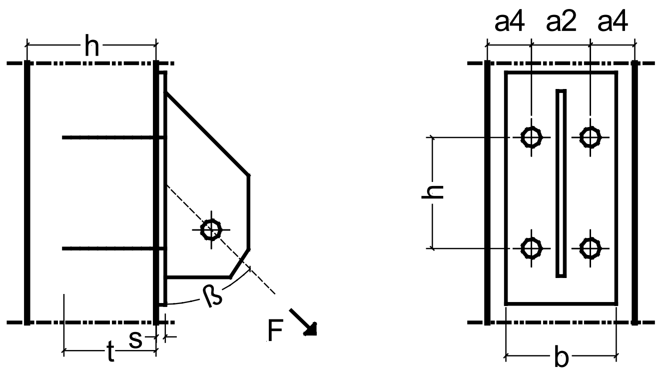
$k_M = 10*MIN(t_1;t_2;t_3) / \sqrt{(M_{y,d} / (f_{h,d} *10* d_N))}$ = 2,98

R_{D1} =	100* $f_{h,d}$ * MIN(t_1;t_2;t_3) * d_N	=	1780,72 N
R_{D2} =	100* 0.5 * $f_{h,d}$ * MIN(t_1;t_2;t_3) * d_N	=	890,36 N
R_{D3} =	36.7 * $f_{h,d}$ * MIN(t_1;t_2;t_3) * dN * (2 * √(1 + 3 / k_M²) - 1)	=	858,26 N
R_{D4} =	155.6 * $f_{h,d}$ * MIN(t_1;t_2;t_3) * d_N / k_M	=	929,80 N
R_D =	0.001 * MIN(R_{D1};R_{D2};R_{D3};R_{D4})	=	0,86 kN

required number of nails n = F_d/(2*R_D) = **8,7**

selected: 3x3=9 nails 42x110 DIN 1151

Wind brace connection:



System:

Beam thickness h = 16,00 cm
Driving depth t = 11,40 cm
Sheet thickness s = 0,60 cm
Angle of tensile force β = 45,00 °
Tensile force F_d = 23,54 kN

Materials: Post

Construction material CM =	SEL("wood/kmod"; CM;)	=	Glulam
Class of load duration CLD =	SEL("wood/kmod"; CLD;)	=	short term
Utility class UC=	SEL("wood/kmod"; UC;)	=	1
⇒ k_{mod} =	TAB("wood/kmod"; kmod; CM=CM; CLD=CLD; UC=UC)	=	0,90
Strength grade SG=	SEL("wood/EC"; SG;)	=	BS14h
ρ_k =	TAB("wood/EC"; ρk; SG=SG)	=	410,00 kg/m³
γ_M =	1,30		

Screws: 4 Sr ∅ 12*120 DIN 571

Screw diameter d = 1,20 cm
$f_{u,k}$ = 300,00 N/mm²
γ_S = 1,10

Minimum distances Rod1 according to Tab.6.23:

a_1 =	7* d	=	8,40 cm
a_2 =	4 * d	=	4,80 cm
$a_{4,t}$ =	3 * d	=	3,60 cm

Design value of bearing stress resistance:

$f_{h,d}$ =	0.082 * ρ_k * (1-0.1*d)*k_{mod} /γ_M	=	20,48 N/mm²
0.8/d		=	0,67 < 1
⇒ calculation as for pins:			
(0.6*(t+s)+4*d)/t		=	1,05 > 1
⇒ d_{ef} =	9 *d	=	10,80 mm
$M_{y,d}$ =	0.8*$f_{u,k}$ *d_{ef}^3/(6*γ_S)	=	45807,71 Nmm
s/(d/2)		=	1,00 < 1
⇒ thin plate			
R_{D1} =	(√(2)-1)*$f_{h,d}$*(t-1.5*d)*d*100	=	9772,52 N
R_{D2} =	1.1 *√(20* $M_{y,d}$ * $f_{h,d}$ *d)	=	5219,54 N
R_D =	0.001 * MIN(R_{D1};R_{D2})	=	**5,22 kN**

Design value for pullout:

$f_{3,d}$ = k_{mod}/γ_M*(1.5+6*d)*√(ρ_k) = 121,96 N/mm²

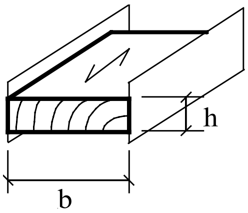
R_d = $f_{3,d}$ * (0.6*(t+s)-d)*0.01 = **7,32 kN**

Combined loads:

$(F_d*SIN(\beta)/(4*R_d))^2+(F_d*COS(\beta)/(4*R_D))^2$ = **0,96 < 1**

Shrinkage

Shrinkage and swelling of wood:



System:

The only appreciable stress is generated ⊥ to the fibre.

Width b =			32,00 cm
Height h =			12,00 cm
Coefficient for the degree of shrinkage and swelling β_{90} =			0,24 %
Strength grade SG=	SEL("wood/EC"; SG;)	=	S10
$E_{90,mean}$ =	TAB("wood/EC"; $E_{90.mean}$; SG=SG)	=	370,00 N/mm²
Timber moisture before w_1 =			10,00 %
Timber moisture after w_2 =			15,00 %

Stress:

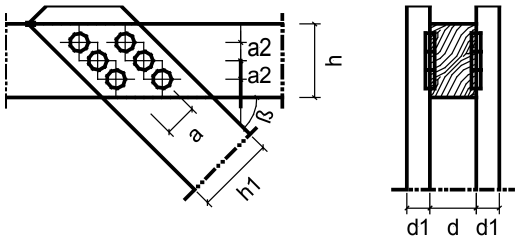
$\sigma_{c,90}$= $E_{90,mean}*\beta_{90}*(w_2-w_1)/200$ = 2,22 N/mm²

Total force:

$F_{\sigma,90}$ = $\sigma_{c,90}$ * b * h = 852,48 N

spec dowel

Diagonal tie connection with special dowels:



System:

Distance a =	8,00 cm
Distance a_2 =	9,00 cm
System angle β =	40,00 °
Beam height h =	30,00 cm
Beam thickness d =	16,00 cm
Strut height h_1 =	18,00 cm
Strut thickness d_1 =	8,00 cm
Number of rows n_z =	2
Tensile force $F_{t,d}$ =	165,00 kN

Construction material CM=	SEL("wood/kmod"; CM;)	=	solid wood
Class of load duration CLD=	SEL("wood/kmod"; CLD;)	=	normal
Utility class UC=	SEL("wood/kmod"; UC;)	=	2
⇒ k_{mod} =	TAB("wood/kmod"; kmod; CM=CM; CLD=CLD; UC=UC)	=	0,80

Transition to DIN 1052-2

F_d = $F_{t,d}/1.35$ = 122,22 kN

Selection of dowel: Split ring connector Type D according to DIN 1052-2, Table 4, 6 or 7 and 8

Dowel ∅ 65 - A with 6 * M12 + 12 * washers 58/6

Number of dowels selected per cut n =	6
per.N_c =	11,00 kN
Dowel height h_c =	2,70 cm
Dowel diameter d_c =	6,50 cm

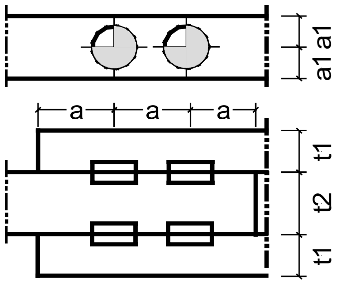
Minimum wood dimensions of the beam from b/a = 110/40
Minimum wood dimensions of the strut from b/a = 100/40

Distance a_1 =			14,00 cm
$a_{2.1}$ =	$d_c+h_c/2$	=	7,85 cm
$a_{3,t}$ =			14,00 cm
$a_{4,strut}$ =	10/2	=	5,00 cm
$a_{4,beam}$ =	11/2	=	5,50 cm
l=	$a_2/SIN(\beta)$	=	14,00 cm
a_1/l		=	**1,00 < 1**
$a_{2.1}/a_2$		=	**0,87 < 1**
$a_{4,beam}/(h/2-a_2)$		=	**0,92 < 1**
$a_{4,strut}/((h_1-a)/2)$		=	**1,00 < 1**
n_{ef} =	MIN(2 + (1- n/n_z / 20) * (n/n_z - 2);6)	=	2,85

Structural verification:

$F_d/(2*n_z*n_{ef}*per.N_c)$ = **0,97 < 1**

Tensile splice with special dowels:



System:

Distance a =	22,00 cm
Distance a_1 =	6,00 cm
Thickness t_1=	8,00 cm
Thickness t_2 =	10,00 cm
Cut surfaces n_z =	2
Tensile force $F_{t,d}$ =	95,00 kN

Construction material CM=	SEL("wood/kmod"; CM;)	=	solid wood
Class of load duration CLD=	SEL("wood/kmod"; CLD;)	=	normal
Utility class UC=	SEL("wood/kmod"; UC;)	=	2
$\Rightarrow k_{mod}$ =	TAB("wood/kmod"; kmod; CM=CM; CLD=CLD; UC=UC)	=	0,80

Transition to DIN 1052-2

F_d = $F_{t,d}$/1.35 = 70,370 kN

Selection of dowel: Split ring connector Type A according to DIN 1052-2, Table 4, 6 or 7

Dowel ∅ 95 - A with 2 * M12 + 4 * washers 58/6

Number of dowels selected per cut n =			3
zul.N_c =			17,00 kN
b_{min}=			12,00 cm
a_{min}=			22,00 cm
a_{min4}=	$b_{min}/2$	=	6,00 cm
a/a_{min}		=	**1,00 < 1**
a_1/a_{min4}		=	**1,00 < 1**

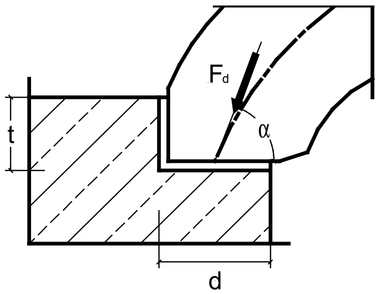
n_{ef} = MIN(2 + (1- n / 20) * (n - 2);6) = 2,85

Structural verification:

$F_d/(n_z*n_{ef}*zul.N_c)$ = **0,73 < 1**

Stress analysis

Arched beam:



System:

Cutting depth t =	12,00 cm
Support length d =	24,00 cm
Beam width b =	16,00 cm
Support angle α =	55,00 °

Materials:

Construction material CM=	SEL("wood/kmod"; CM;)	=	Glulam
Class of load duration CLD=	SEL("wood/kmod"; CLD;)	=	normal
Utility class UC=	SEL("wood/kmod"; UC;)	=	1
$\Rightarrow k_{mod}$ =	TAB("wood/kmod"; kmod; CM=CM; CLD=CLD; UC=UC)	=	0,80
Strength grade SG=	SEL("wood/EC"; SG;)	=	BS14k
ρ_k =	TAB("wood/EC"; ρk; SG=SG)	=	410,00 kg/m³
Rectangular shear $f_{c,0,k}$ =	TAB("wood/EC"; fc,0.k; SG=SG)	=	27,50 N/mm²
Rectangular shear $f_{c,90,k}$ =	TAB("wood/EC"; fc,90.k; SG=SG)	=	5,50 N/mm²
γ_M =	1,30		

Load:

F_d = 300,00 kN

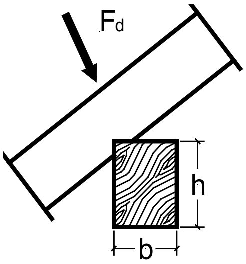
Calculation:

$f_{c,0,d}$ =	$f_{c,0,k} * k_{mod} / \gamma_M$	=	16,92 N/mm²
$f_{c,90,d}$ =	$f_{c,90,k} * k_{mod} / \gamma_M$	=	3,38 N/mm²
Vertical supporting force:			
β =	$90 - \alpha$	=	35,00 °
$k_{c,\beta}$ =	$1 /((f_{c,0,d}/f_{c,90,d})*(SIN(\beta))^2+(COS(\beta))^2)$	=	0,431
$V_{d,max}$ =	$100* b*d*k_{c,\beta}*f_{c,0,d}*0.001$	=	280,03 kN
Horizontal supporting force:			
$k_{c,\alpha}$ =	$1 /((f_{c,0,d}/f_{c,90,d})*(SIN(\alpha))^2+(COS(\alpha))^2)$	=	0,271
$H_{d,max}$ =	$100* b*d*k_{c,\alpha}*f_{c,0,d}*0.001$	=	176,08 kN
$F_{d,h}$ =	$F_d * COS(\alpha)$	=	172,07 kN
$F_{d,v}$ =	$F_d * SIN(\alpha)$	=	245,75 kN

Structural verifications:

$F_{d,h} / H_{d,max}$	=	**0,98 < 1**
$F_{d,v} / V_{d,max}$	=	**0,88 < 1**

Centre purlin with 2-axis deflection:



Materials:

Construction material CM=	SEL("wood/kmod"; CM;)	=	solid wood
Class of load duration CLD=	SEL("wood/kmod"; CLD;)	=	short term
Utility class UC=	SEL("wood/kmod"; UC;)	=	2
$\Rightarrow k_{mod}$ =	TAB("wood/kmod"; kmod; CM=CM; CLD=CLD; UC=UC)	=	0,90
Strength grade SG=	SEL("wood/EC"; SG;)	=	S10
$f_{m,k}$ =	TAB("wood/EC"; fm.k; SG=SG)	=	24,00 N/mm²
γ_M =	1,30		

Load:

Loading moments as a result of the sloping load

$M_{y,d}$ = 20,00 kNm

$M_{z,d}$ = 5,00 kNm

Calculation:

$f_{m,d}$ =	$f_{m,k} * k_{mod} / \gamma_M$	=	16,62 N/mm²
Approximation $W_{y,req}$ =	$1000*(M_{y,d} + M_{z,d}) / f_{m,d}$	=	1504,21 cm³

selected: Cross section:

b = 16,00 cm

h = 24,00 cm

W_y = $b * h^2 / 6$ = 1536,00 cm³

W_z = $h * b^2 / 6$ = 1024,00 cm³

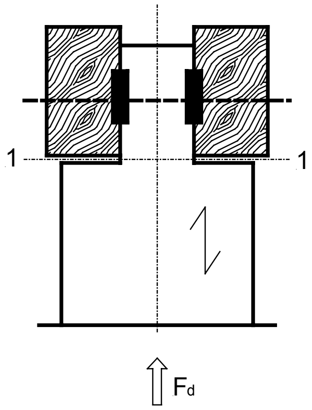
Structural verification:

k_m = 0,70 for rectangular cross section

otherwise k_m = 1.0

$(M_{y,d}/W_y*1000+k_m*M_{z,d}/W_z*1000)/f_{m,d}$ = **<u>0,99 < 1</u>**

Compression member connection



System:

Cross-sectional width in cut 1-1 b =	8,00 cm
Cross-sectional in cut 1-1 h =	16,00 cm

Materials:

Construction material CM=	SEL("wood/kmod"; CM;)	=	solid wood
Class of load duration CLD=	SEL("wood/kmod"; CLD;)	=	normal
Utility class UC=	SEL("wood/kmod"; UC;)	=	2
⇒ k_{mod} =	TAB("wood/kmod"; kmod; CM=CM; CLD=CLD; UC=UC)	=	0,80
Strength grade SG=	SEL("wood/EC"; SG;)	=	S10
ρ_k =	TAB("wood/EC"; ρk; SG=SG)	=	380,00 kg/m³
Rectangular shear $f_{c,0,k}$ =	TAB("wood/EC"; fc,0.k; SG=SG)	=	21,00 N/mm²
γ_M =	1,30		

Load:

F_d = 112,00 kN

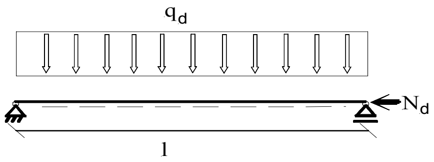
Calculation:

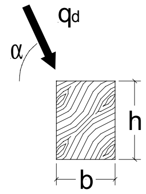
A =	b*h	=	128,00 cm²
$f_{c,0.d}$ =	$f_{c,0,k} * k_{mod} / \gamma_M$	=	12,92 N/mm²
$\sigma_{c,0.d}$ =	F_d * 10 / A	=	8,75 N/mm²

Structural verification:

$\sigma_{c,0.d} / f_{c,0.d}$ = **<u>0,68 < 1</u>**

Structural analysis of deflection in two directions and pressure:





System:

Beam width b =	18,00 cm
Beam height h =	24,00 cm
Beam length l =	3,50 m
Load angle α =	75,00 °

Materials:

Construction material CM=	SEL("wood/kmod"; CM;)	=	solid wood
Class of load duration CLD=	SEL("wood/kmod"; CLD;)	=	normal
Utility class UC=	SEL("wood/kmod"; UC;)	=	1
$\Rightarrow k_{mod}$ =	TAB("wood/kmod"; kmod; CM=CM; CLD=CLD; UC=UC)	=	0,80
Strength grade SG=	SEL("wood/EC"; SG;)	=	S10
ρ_k =	TAB("wood/EC"; ρk; SG=SG)	=	380,00 kg/m³
Rectangular shear $f_{c,0,k}$ =	TAB("wood/EC"; fc,0.k; SG=SG)	=	21,00 N/mm²
$f_{m,k}$ =	TAB("wood/EC"; fm.k; SG=SG)	=	24,00 N/mm²
γ_M =	1,30		

Load:

q_d =	13,21 kN/m
N_d =	94,50 kN

Calculation:

$q_{d,y}$ =	q_d * SIN(α)	=	12,76 kN/m
$q_{d,z}$ =	q_d * COS(α)	=	3,42 kN/m
$M_{y,d}$ =	$q_{d,y}$ * l² / 8	=	19,54 Nmm
$M_{z,d}$ =	$q_{d,z}$ * l² / 8	=	5,24 Nmm
$f_{c,0,d}$ =	$f_{c,0,k}$ * k_{mod} / γ_M	=	12,92 N/mm²
$f_{m,d}$ =	$f_{m,k}$ * k_{mod} / γ_M	=	14,77 N/mm²
W_y =	b * h² / 6	=	1728,00 cm³
W_z =	h * b² / 6	=	1296,00 cm³
A =	b * h / 1	=	432,00 cm²

k_m = 0,70 for rectangular cross section

otherwise k_m = 1.0

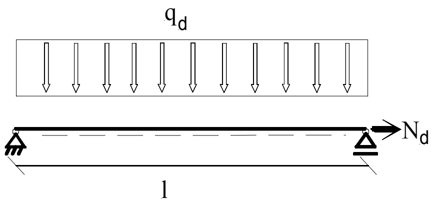
$\sigma_{c,0,d}$ =	10 * N_d / A	=	2,19 N/mm²

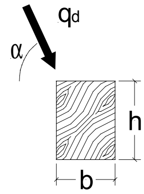
Structural verifications:

$(\sigma_{c,0,d}/f_{c,0,d})^2+(M_{y,d}/W_y*1000+k_m*M_{z,d}/W_z*1000)/f_{m,d}$ = **0,99 < 1**

$(\sigma_{c,0,d}/f_{c,0,d})^2+(k_m*M_{y,d}/W_y*1000+M_{z,d}/W_z*1000)/f_{m,d}$ = **0,84 < 1**

Structural analysis of deflection in two directions and tension:





System:

Beam width b = 18,00 cm
Beam height h = 24,00 cm
Beam length l = 3,50 m
Load angle α = 75,00 m

Materials:

Construction material CM= SEL("wood/kmod"; CM;) = solid wood
Class of load duration CLD= SEL("wood/kmod"; CLD;) = normal
Utility class UC= SEL("wood/kmod"; UC;) = 1
$\Rightarrow k_{mod}$ = TAB("wood/kmod"; kmod; CM=CM; CLD=CLD; UC=UC) = 0,80
Strength grade SG= SEL("wood/EC"; SG;) = S10
ρ_k = TAB("wood/EC"; ρk; SG=SG) = 380,00 kg/m³
$f_{t,0,k}$ = TAB("wood/EC"; ft.0.k; SG=SG) = 14,00 N/mm²
$f_{m,k}$ = TAB("wood/EC"; fm.k; SG=SG) = 24,00 N/mm²
γ_M = 1,30

Load:

q_d = 10,21 kN/m
N_d = 47,50 kN

Calculation:

$q_{d,y} = q_d * SIN(\alpha)$ = 9,86 kN/m
$q_{d,z} = q_d * COS(\alpha)$ = 2,64 kN/m
$M_{y,d} = q_{d,y} * l^2 / 8$ = 15,10 Nmm
$M_{z,d} = q_{d,z} * l^2 / 8$ = 4,04 Nmm

$f_{t,0,d} = f_{t,0,k} * k_{mod} / \gamma_M$ = 8,62 N/mm²
$f_{m,d} = f_{m,k} * k_{mod} / \gamma_M$ = 14,77 N/mm²

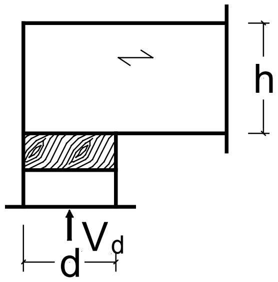
$W_y = b * h^2 / 6$ = 1728,00 cm³
$W_z = h * b^2 / 6$ = 1296,00 cm³
$A = b * h / 1$ = 432,00 cm²

k_m = 0,70 for rectangular cross section
otherwise k_m = 1.0

Structural verification:

$10*N_d/A/f_{t,0,d}+(M_{y,d}/W_y*1000+k_m*M_{z,d}/W_z*1000)/f_{m,d}$ = **<u>0,87 < 1</u>**

End support of a laminated timber beam



System:

Width of laminated timber beam b = 18,00 cm

Materials:

Construction material CM=	SEL("wood/kmod"; CM;)	=	Glulam
Class of load duration CLD=	SEL("wood/kmod"; CLD;)	=	normal
Utility class UC=	SEL("wood/kmod"; UC;)	=	1
$\Rightarrow k_{mod}$ =	TAB("wood/kmod"; kmod; CM=CM; CLD=CLD; UC=UC)	=	0,80
Strength grade SG=	SEL("wood/EC"; SG;)	=	BS11
Rectangular shear $f_{c,90,k}$ =	TAB("wood/EC"; fc,90.k; SG=SG)	=	5,50 N/mm²
$f_{m,k}$ =	TAB("wood/EC"; fm.k; SG=SG)	=	24,00 N/mm²
γ_M =	1,30		

Load:

V_d = 98,00 kN

Calculation:

$f_{c,90,d}$ = $f_{c,90,k} * k_{mod} / \gamma_M$ = 3,38 N/mm²

Assumption: l > 150 mm otherwise $k_{c,90}$ according to Tab. 5.1.5

$\Rightarrow k_{c,90}$ = 1,00

erf_A = V_d *10 / ($f_{c,90,d} * k_{c,90}$) = 289,94 cm²

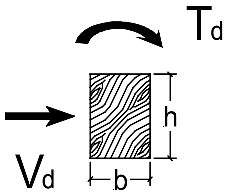
erf_d = erf_A / b = 16,11 cm

sel. d = 17,00 cm

Structural verification:

erf_d / d = <u>**0,95 < 1**</u>

Stress analysis of shear force and torsion:



System:

Support width b =	30,00 cm
Support depth h =	14,00 cm

Materials:

Construction material CM=	SEL("wood/kmod"; CM;)	=	Glulam
Class of load duration CLD=	SEL("wood/kmod"; CLD;)	=	short term
Utility class UC=	SEL("wood/kmod"; UC;)	=	2
$\Rightarrow k_{mod}$ =	TAB("wood/kmod"; kmod; CM=CM; CLD=CLD; UC=UC)	=	0,90
Strength grade SG=	SEL("wood/EC"; SG;)	=	BS16k
$f_{v,g,k}$ =	TAB("wood/EC"; fv.k; SG=SG)	=	2,70 N/mm²
γ_M =	1,30		

Load:

relevant shear force V_d =	18,00 kN
relevant torsional moment T_d =	1,74 kNm

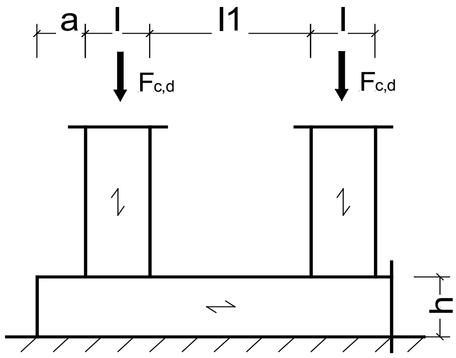
Calculation:

A =	b*h	=	420,00 cm²
η =	1+0.6/(b/h)	=	1,28
$\tau_{tor,d}$ =	$3000 \cdot T_d \cdot \eta/(b \cdot h^2)$??	=	1,14 N/mm²
$\tau_{v,d}$ =	$30 \cdot V_d/(2 \cdot A)$	=	0,64 N/mm²
$f_{v,d}$ =	$k_{mod} \cdot f_{v,g,k} / \gamma_M$	=	1,87 N/mm²

Structural verifications:

Shear:	$\tau_{v,d} / f_{v,d}$	=	**0,34 < 1**
Torsion:	$\tau_{tor,d} / f_{v,d}$	=	**0,61 < 1**
Combination:	$\tau_{tor,d} / f_{v,d} + (\tau_{v,d} / f_{v,d})^2$??	=	**0,73 < 1**

Stud:



System:

Length of wood beam projection a =	6,00 cm
Support length l =	6,00 cm
Support depth d =	12,00 cm
clear distance between studs l_1 =	34,00 cm

Materials:

Construction material CM=	SEL("wood/kmod"; CM;)	=	solid wood
Class of load duration CLD=	SEL("wood/kmod"; CLD;)	=	short term
Utility class UC=	SEL("wood/kmod"; UC;)	=	1
⇒ k_{mod} =	TAB("wood/kmod"; kmod; CM=CM; CLD=CLD; UC=UC)	=	0,90
Strength grade SG=	SEL("wood/EC"; SG;)	=	S10
ρ_k =	TAB("wood/EC"; ρk; SG=SG)	=	380,00 kg/m³
$f_{c,90,k}$ =	TAB("wood/EC"; fc.90.k; SG=SG)	=	5,00 N/mm²
$f_{m,k}$ =	TAB("wood/EC"; fm.k; SG=SG)	=	24,00 N/mm²
γ_M =			1,30

Load:

$F_{c,d}$ =	20,00 kN

Calculation:

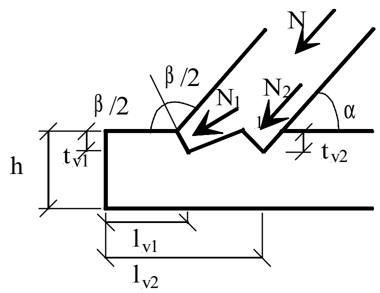
$f_{c,90.d}$ =	$k_{mod} * f_{c,90,k} / \gamma_M$	=	3,46 N/mm²
for:	$15 / l_1$	=	0,44 < 1
and:	l / 15	=	0,40 < 1
⇒according to Tab. 5.1.5 $k_{c,90}$ =	1+a*(150-10*l)/1700	=	1,32
A =	l * d	=	72,00 cm²
$\sigma_{c,90.d}$ =	$10 * F_{c,d} / A$	=	2,78 N/mm²

Structural verification:

$\sigma_{c,90.d} / (k_{c,90} * f_{c,90.d})$	=	0,61 < 1

System

Acceptable force of a double shoulder joint:



System:

Beam height h =	22,00 cm
Beam width b =	14,00 cm
Length of wood beam projection l_{v1} =	22,00 cm
Length of wood beam projection l_{v2} =	30,00 cm
Shoulder depth t_{v1} =	3,50 cm
Shoulder depth t_v =	4,50 cm
Angle α =	45,00 °

Comply with structural rules for shoulder depth and length of wood beam projection.

Materials:

Construction material CM=	SEL("wood/kmod"; CM;)	=	solid wood
Class of load duration CLD=	SEL("wood/kmod"; CLD;)	=	normal
Utility class UC=	SEL("wood/kmod"; UC;)	=	1
$\Rightarrow k_{mod}$ =	TAB("wood/kmod"; kmod; CM=CM; CLD=CLD; UC=UC)	=	0,80
Strength grade SG=	SEL("wood/EC"; SG;)	=	S13
ρ_k =	TAB("wood/EC"; ρk; SG=SG)	=	380,00 kg/m³
$f_{v,k}$ =	TAB("wood/EC"; fv.k; SG=SG)	=	2,50 N/mm²
$f_{c,0,k}$ =	TAB("wood/EC"; fc,0.k; SG=SG)	=	23,00 N/mm²
$f_{c,90,k}$ =	TAB("wood/EC"; fc.90.k; SG=SG)	=	5,00 N/mm²
γ_M =	1,30		

Load:

N_d = 86,00 kN

Calculation:

$f_{v,d}$ =	$k_{mod} * f_{v,k} / \gamma_M$	=	1,54 N/mm²
$f_{c,0,d}$ =	$k_{mod} * f_{c,0,k} / \gamma_M$	=	14,15 N/mm²
$f_{c,90,d}$ =	$k_{mod} * f_{c,90,k} / \gamma_M$	=	3,08 N/mm²

with approximation:

k_F =	$1 / ((f_{c,0,d}/f_{c,90,d})*(SIN(\alpha))^2*COS(\alpha)+COS(\alpha)^3)$	=	0,51
k_s =	$4 / ((f_{c,0,d}/f_{c,90,d})*(SIN(\alpha))^2+(COS(\alpha))^2+2*COS(\alpha)+1)$	=	0,77

$l_{v1,min}$ =	$10*N_d/2 *COS(\alpha)/(b * f_{v,d})$	=	14,10 cm
$l_{v1,1}$ =	$8* t_v$	=	36,00 cm
$l_{v1,min} / l_{v1,1}$		=	0,39 < 1
$l_{v1,min} / l_{v1}$		=	**0,64 < 1**

$l_{v2,min}$ =	$10 \cdot N_d/2 \cdot COS(\alpha)/(b \cdot f_{v,d})$	=	14,10 cm
$l_{v2,1}$ =	$8 \cdot t_v$	=	36,00 cm
$l_{v2,min} / l_{v2,1}$		=	0,39 < 1
$l_{v2,min} / l_{v2}$		=	**0,47 < 1**
$R_{F,d}$ =	$b \cdot t_v \cdot f_{c,0,d} \cdot k_F / 10$	=	**45,46 kN**
$R_{S,d}$ =	$b \cdot t_v \cdot f_{c,0,d} \cdot k_s / 10$	=	**68,64 kN**

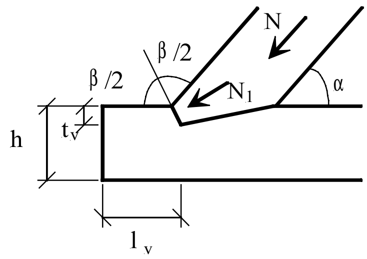
detailed calculation:

$k_{c,\alpha}$ =	$1 / ((f_{c,0,d}/f_{c,90,d}) \cdot (SIN(\alpha))^2 + (COS(\alpha))^2)$	=	0,358
$R_{F,d}$ =	$k_{c,\alpha} \cdot f_{c,0,d} \cdot b \cdot t_v / COS(\alpha)/10$	=	**45,13 kN**
$k_{c,\alpha}$ =	$1 / ((f_{c,0,d}/f_{c,90,d}) \cdot (SIN(\alpha/2))^2 + (COS(\alpha/2))^2)$	=	0,655
$f_{c,0,5\alpha,d}$ =	$k_{c,\alpha} \cdot f_{c,0,d}$	=	9,27 N/mm²
$R_{S,d}$ =	$f_{c,0,5\alpha,d} \cdot \alpha \cdot b / ((COS(\alpha/2))^2)/100$	=	**68,42 kN**

Structural verification:

$N_d / (R_{F,d}+R_{S,d})$ = **0,76 < 1**

Acceptable force of a face staggered joint:



System:

Beam height h =	22,00 cm
Beam width b =	14,00 cm
Length of wood beam projection l_v =	22,00 cm
Shoulder depth t_v =	4,50 cm
Angle α =	45,00 °

Comply with structural rules for shoulder depth and length of wood beam projection.

Materials:

Construction material CM=	SEL("wood/kmod"; CM;)	=	solid wood
Class of load duration CLD=	SEL("wood/kmod"; CLD;)	=	normal
Utility class UC=	SEL("wood/kmod"; UC;)	=	1
$\Rightarrow k_{mod}$ =	TAB("wood/kmod"; kmod; CM=CM; CLD=CLD; UC=UC)	=	0,80
Strength grade SG=	SEL("wood/EC"; SG;)	=	S13
$f_{v,k}$ =	TAB("wood/EC"; fv.k; SG=SG)	=	2,50 N/mm²
$f_{c,0,k}$ =	TAB("wood/EC"; fc.0.k; SG=SG)	=	23,00 N/mm²
$f_{c,90,k}$ =	TAB("wood/EC"; fc.90.k; SG=SG)	=	5,00 N/mm²
γ_M =	1,30		

Load:

N_d = 63,00 kN

Calculation:

$f_{v,d}$ =	$k_{mod} * f_{v,k} / \gamma_M$	=	1,54 N/mm²
$f_{c,0,d}$ =	$k_{mod} * f_{c,0,k} / \gamma_M$	=	14,15 N/mm²
$f_{c,90,d}$ =	$k_{mod} * f_{c,90,k} / \gamma_M$	=	3,08 N/mm²

with approximation:

k_s =	$4 / ((f_{c,0,d}/f_{c,90,d})*(SIN(\alpha))^2+(COS(\alpha))^2+2*COS(\alpha)+1)$	=	0,77
$l_{v,min}$ =	$10*N_d *COS(\alpha)/(b * f_{v,d})$	=	20,66 cm
$l_{v,1}$ =	$8* t_v$	=	36,00 cm
$l_{v,min} / l_{v,1}$		=	0,57 < 1
$l_{v,min} / l_v$		=	**0,94 < 1**
$R_{S,d}$ =	$b * t_v * f_{c,0,d} * k_s / 10$	=	**68,64 kN**

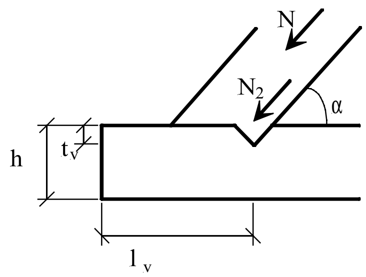
detailed calculation:

$k_{c,\alpha}$ =	$1 / ((f_{c,0,d}/f_{c,90,d}) * (SIN(\alpha/2))^2 + (COS(\alpha/2))^2)$	=	0,655
$f_{c,0,5\alpha,d}$ =	$k_{c,\alpha} * f_{c,0,d}$	=	9,27 N/mm²
$R_{S,d}$ =	$f_{c,0,5\alpha,d} * \alpha * b / ((COS(\alpha/2))^2)/100$	=	**68,42 kN**

Structural verification:

$N_d / R_{S,d}$ = **0,92 < 1**

Acceptable force of a heel staggered joint:



System:

Beam height h =	22,00 cm
Beam width b =	14,00 cm
Length of wood beam projection l_v =	22,00 cm
Shoulder depth t_v =	4,50 cm
Angle α =	45,00 °

Comply with structural rules for shoulder depth and length of wood beam projection.

Materials:

Construction material CM=	SEL("wood/kmod"; CM;)	=	solid wood
Class of load duration CLD=	SEL("wood/kmod"; CLD;)	=	normal
Utility class UC=	SEL("wood/kmod"; UC;)	=	1
⇒ k_{mod} =	TAB("wood/kmod"; kmod; CM=CM; CLD=CLD; UC=UC)	=	0,80
Strength grade SG=	SEL("wood/EC"; SG;)	=	S13
$f_{v,k}$ =	TAB("wood/EC"; fv.k; SG=SG)	=	2,50 N/mm²
$f_{c,0,k}$ =	TAB("wood/EC"; fc.0.k; SG=SG)	=	23,00 N/mm²
$f_{c,90,k}$ =	TAB("wood/EC"; fc.90.k; SG=SG)	=	5,00 N/mm²
γ_M =	1,30		

Load:

N_d = 43,00 kN

Calculation:

$f_{v,d}$ =	$k_{mod} * f_{v,k} / \gamma_M$	=	1,54 N/mm²
$f_{c,0,d}$ =	$k_{mod} * f_{c,0,k} / \gamma_M$	=	14,15 N/mm²
$f_{c,90,d}$ =	$k_{mod} * f_{c,90,k} / \gamma_M$	=	3,08 N/mm²

with approximation:

k_F =	$1 / ((f_{c,0,d}/f_{c,90,d})*(SIN(\alpha))^2*COS(\alpha)+COS(\alpha)^3)$	=	0,51
$l_{v,min}$ =	$10*N_d *COS(\alpha)/(b * f_{v,d})$	=	14,10 cm
$l_{v,1}$ =	$8* t_v$	=	36,00 cm
$l_{v,min} / l_{v,1}$		=	0,39 < 1
$l_{v,min} / l_v$		=	**0,64 < 1**
$R_{F,d}$ =	$b * t_v * f_{c,0,d} * k_F / 10$	=	**45,46 kN**

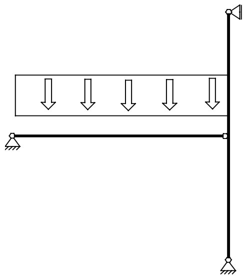
detailed calculation:

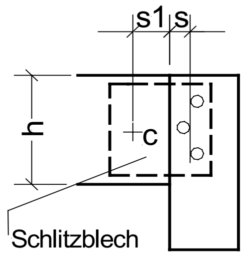
$k_{c,\alpha}$ =	$1 / ((f_{c,0,d}/f_{c,90,d}) * (SIN(\alpha))^2 + (COS(\alpha))^2)$	=	0,358
R_d =	$k_{c,\alpha} * f_{c,0,d} * b * t_v / COS(\alpha)/10$	=	**45,13 kN**

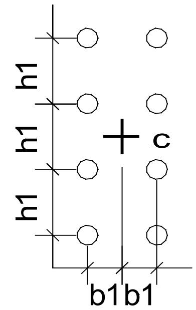
Structural verification:

N_d / R_d = **0,95 < 1**

Connection of a binding joist to a support:







System:

Centroidal distance s =	16,00 cm
Centroidal distance s_1 =	5,00 cm
Dowel distance b_1 =	5,00 cm
Dowel distance h_1 =	8,00 cm
Thickness of slotted plate m =	1,00 cm
Width of binding joist b =	16,00 cm

Materials:

Construction material CM=	SEL("wood/kmod"; CM;)	=	Glulam
Class of load duration CLD=	SEL("wood/kmod"; CLD;)	=	normal
Utility class UC=	SEL("wood/kmod"; UC;)	=	1
⇒ k_{mod} =	TAB("wood/kmod"; kmod; CM=CM; CLD=CLD; UC=UC)	=	0,80
Strength grade SG=	SEL("wood/EC"; SG;)	=	BS11
ρ_k =	TAB("wood/EC"; ρk; SG=SG)	=	410,00 kg/m³
γ_M =	1,30		
γ_S =	1,10		

Load at tie point:

$V_{c,d}$ =	34,60 kN		
$M_{c,d}$ =	$0{,}01 \cdot V_{c,d} \cdot (s_1+s)$	=	7,27 kNm

Geometric values:

r_1 =	$\sqrt{b_1^2+(h_1/2)^2}$	=	6,4 cm
r_2 =	$\sqrt{b_1^2+(h_1 \cdot 1{,}5)^2}$	=	13,0 cm
α_M =	ATAN($b_1/(h_1 \cdot 1{,}5)$)	=	22,62 °

Calculation:

Drift pin forces:

as the result of shear force $F_{V,d}$ =	$V_{c,d} / 8$	=	4,33 kN
as the result of moment $F_{M,d}$ =	$100 \cdot M_{c,d} \cdot r_2/(4 \cdot (r_1^2+r_2^2))$	=	11,25 kN

Components:

$F_{M2,d,V}$ =	$F_{M,d} \cdot \sin(\alpha_M)$	=	4,33 kN
$F_{M2,d,H}$ =	$F_{M,d} \cdot \cos(\alpha_M)$	=	10,38 kN
$F_{d,max}$ =	$\sqrt{(F_{M2,d,V}+F_{V,d})^2+F_{M2,d,H}^2}$	=	13,52 kN
α =	ATAN($(F_{M2,d,V}+F_{V,d})/F_{M2,d,H}$)	=	39,84 °

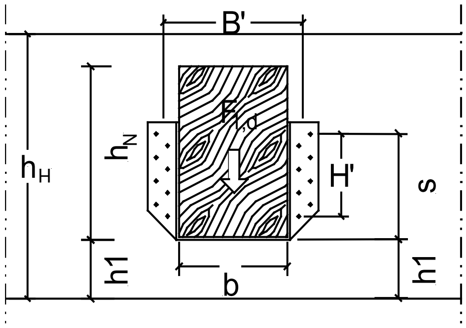
selected: Dowel DPin ∅ 16mm

d =	1,60 cm		
$f_{u,k}$ =	360,0 N/mm²		
$M_{y,d}$ =	$0{,}8 \cdot f_{u,k} \cdot d^3/(6 \cdot \gamma_S)$	=	178,7 kNmm
$f_{h,0,d}$ =	$0{,}082 \cdot \rho_k \cdot (1-0{,}1 \cdot d) \cdot k_{mod}/\gamma_M$	=	17,38 N/mm²
k_{90} =	$1{,}35 + 0{,}15 \cdot d$	=	1,59
$f_{h,1,d}$ =	$f_{h,0,d}/(k_{90} \cdot (SIN(\alpha))^2+(COS(\alpha))^2)$	=	13,99 N/mm²
t_1 =	$(b-m)/2$	=	7,50 cm
R_{D1} =	$100 \cdot f_{h,1,d} \cdot t_1 \cdot d$	=	16788 N
R_{D2} =	$110 \cdot f_{h,1,d} \cdot t_1 \cdot d \cdot (\sqrt{(2+4 \cdot M_{y,d}/(f_{h,1,d} \cdot d \cdot t_1^2))}-1)$	=	11124,52 N
R_{D3} =	$150 \cdot \sqrt{(2 \cdot M_{y,d} \cdot f_{h,1,d} \cdot d)}$	=	13416,44 N
R_D =	$0{,}001 \cdot MIN(R_{D1};R_{D2};R_{D3})$	=	**11,12 kN**

Structural verification:

$F_{d,max} / (2 \cdot R_D)$ = **0,61 < 1**

Joist hanger:



System:

Height of principal beam h_H =	32,00 cm
Height of short-tie beam h_N =	24,00 cm
Joist hanger distance h_1 =	6,00 cm
Nail distance s =	15,20 cm

Load:

$F_{1,d}$ =	12,00 kN

Materials:

Principal beam: 120mm*380mm

Construction material CM=	SEL("wood/kmod"; CM;)	=	Glulam
Class of load duration CLD=	SEL("wood/kmod"; CLD;)	=	normal
Utility class UC=	SEL("wood/kmod"; UC;)	=	2
$\Rightarrow k_{mod}$ =	TAB("wood/kmod"; kmod; CM=CM; CLD=CLD; UC=UC)	=	0,80
Strength grade SG=	SEL("wood/EC"; SG;)	=	BS11
ρ_k =	TAB("wood/EC"; ρk; SG=SG)	=	410,00 kg/m³
$f_{t,90,g,k}$ =	TAB("wood/EC"; ft.90.k; SG=SG)	=	0,45 N/mm²
γ_M =	1,30		

Short-tie beam: 140mm*240mm NH S 10

selected: GH joist hanger 04 140*160 with 14 RNä 4.0x60

Horizontal distance between centroidal axis of nails B' =	18,60 cm
Vertical Nail distance H' =	12,00 cm
Joist hanger thickness d_b =	0,20 cm
Nail diameter d_N =	0,40 cm
Nail length l_N =	6,00 cm
Number of nails n_N =	14
According to manufacturer's table $R_{0.d}$ =	16,40 kN

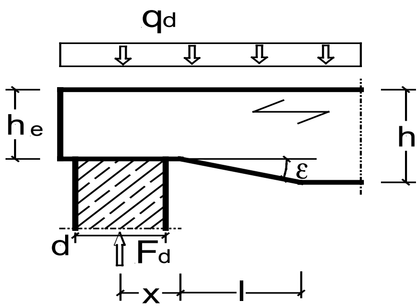
f=	$1/(1-0.93*(s+h_1)/h_H)$	=	2,61
t_{ef} =	$MIN(12*d_N ;l_N-d_b)$	=	4,80 cm
$f_{t,90.d}$ =	$k_{mod} /\gamma_M*f_{t,90,g,k}$	=	0,28 N/mm²

$R_{t,90.d}$ =	$0.0055*f*(10*t_{ef})^{0.8}*(10*h_H+4*\sqrt{(100*B'*H')})^{0.8}*f_{t,90.d}$	=	20,86 kN
R_d =	$MIN(R_{t,90.d} ;R_{0.d})$	=	16,40 kN

Structural verification:

$F_{1,d}/R_d$ = <u>**0,73 < 1**</u>

Notch joist



System:

Cross-sectional width b =	14,00 cm
Support length d =	18,00 cm
Cross sectional height h =	88,00 cm
Cross sectional height at footing h_e =	78,00 cm
Notch distance x =	13,00 cm
Notch length l =	20,00 cm
Beam length l_1 =	850,00 cm

Materials:

Construction material CM=	SEL("wood/kmod"; CM;)	=	Glulam
Class of load duration CLD=	SEL("wood/kmod"; CLD;)	=	short term
Utility class UC=	SEL("wood/kmod"; UC;)	=	2
⇒ k_{mod} =	TAB("wood/kmod"; kmod; CM=CM; CLD=CLD; UC=UC)	=	0,90
Strength grade SG=	SEL("wood/EC"; SG;)	=	BS14k
ρ_k =	TAB("wood/EC"; ρk; SG=SG)	=	410,00 kg/m³
$f_{v,g,k}$ =	TAB("wood/EC"; fv.k; SG=SG)	=	2,70 N/mm²
$f_{c,90,k}$ =	TAB("wood/EC"; fc.90.k; SG=SG)	=	5,50 N/mm²
for solid wood k_n =	IF(CM="Glulam";6,5;5)	=	6,50
γ_M =			1,30

Load:

Supporting force F_d =	95,30 kN
Line load q_d =	2,80 kN/m

Calculation for splintering:

Maximum design shear force:

for uniformly distributed load k_r =	$1-2*h/l_1$	=	0,79
$F_{d,b}$ =	$k_r * F_d$	=	75,29 kN

for individual load k_F =(0.5-h/l_1)*e/h with e the distance of the force from footing k

and $F_{b,d}$ =k_F * F_d

$f_{v,d}$ =	k_{mod} * $f_{v,g,k}$ / γ_M	=	1,87 N/mm²

l=MAX(l;0.01)

ε =	ATAN((h - h_e)/l)	=	26,57 °
k_ε =	$1+(1.1*(TAN(\varepsilon))^{-1.5})/(\sqrt{(h*10)})$	=	1,10
α =	h_e / h	=	0,89
k_{90} =	$k_n/(\sqrt{(h*10)}*(\sqrt{(\alpha*(1-\alpha))}+0,8*(x/h)*\sqrt{(1/\alpha-\alpha^2)}))$	=	0,575
k_v =	MIN(1;k_{90}*k_ε)	=	0,63

Structural verification:

$(1500*F_{d,b}/(100*b*h_e))/(k_v*f_{v,d})$	=	<u>**0,88 < 1**</u>

Calculation of bearing pressure:

$f_{c,90,d}$ =	$f_{c,90,k} * k_{mod} / \gamma_M$	=	3,81 N/mm²

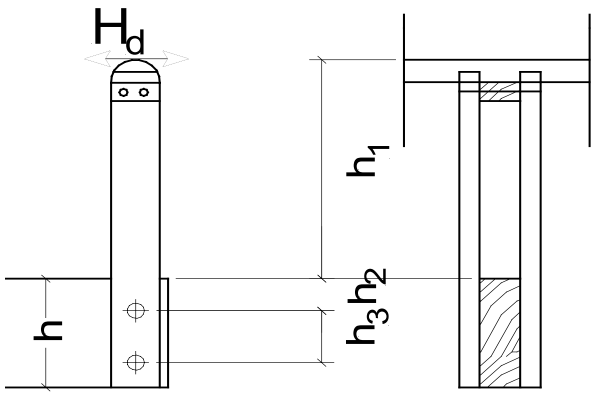
Assumption: Support length t > 150 mm otherwise $k_{c,90}$ according to Tab. 5.1.5

⇒ $k_{c,90}$ =			1,0
erf_A =	F_d *10 / ($f_{c,90,d} * k_{c,90}$)	=	250,13 N/mm²
erf_d =	erf_A / b	=	17,87 mm

Structural verification:

erf_d / d		=	**0,99 < 1**

Rail post:



System:

Post distance l =	1,70 m
Rail height h_1 =	100,00 cm
Dowel distance h_2 =	5,00 cm
Dowel distance h_3 =	23,00 cm
γ_Q =	1,50

Load: according to DIN 1055-3

H' =			1,00 kN/m
H_d =	γ_Q * l * H'	=	2,55 kN/m

Materials:

Construction material CM=	SEL("wood/kmod"; CM;)	=	Glulam
Class of load duration CLD=	SEL("wood/kmod"; CLD;)	=	short term
Utility class UC=	SEL("wood/kmod"; UC;)	=	1
⇒ k_{mod} =	TAB("wood/kmod"; kmod; CM=CM; CLD=CLD; UC=UC)	=	0,90
Strength grade SG=	SEL("wood/EC"; SG;)	=	BS11
$f_{t,90.g,k}$ =	TAB("wood/EC"; ft,90.k; SG=SG)	=	0,45 N/mm²
γ_M =	1,30		

Calculation:

$M_{c,d}$ =	$0,01*H_d*(h_1+h_2+h_3/2)$	=	2,97 kNm
$F_{1,d}$ =	$H_d/2+M_{c,d}/(h_3*0,01)$	=	14,19 kN
$F_{2,d}$ =	$M_{c,d}/(h_3*0,01)-H_d/2$	=	11,64 kN

Transition to DIN 1052-2:

F_1 =	$MAX(F_{1,d};F_{2,d})/1,4$	=	10,14 kN

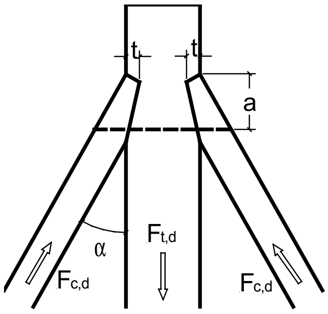
selected: 2 DPin ∅ 85 - D

mit zul_N_c = 14,50 kN

Structural verification:

F_1/ zul_N_c = **0,70 < 1**

Suspender:



System:

Height of diagonal brace h =	14,00 cm
Width of diagonal brace b =	14,00 cm
Height of suspender h_H =	18,00 cm
Width of suspender b_H =	14,00 cm
Shoulder depth t_v =	3,00 cm
Diameter of pin d =	1,20 cm
Angle α =	45,00 °

Comply with structural rules for shoulder depth and length of wood beam projection.

Materials:

Construction material CM=	SEL("wood/kmod"; CM;)	=	solid wood
Class of load duration CLD=	SEL("wood/kmod"; CLD;)	=	normal
Utility class UC=	SEL("wood/kmod"; UC;)	=	1
⇒ k_{mod} =	TAB("wood/kmod"; kmod; CM=CM; CLD=CLD; UC=UC)	=	0,80
Strength grade SG=	SEL("wood/EC"; SG;)	=	S13
$f_{t,0,k}$ =	TAB("wood/EC"; ft.0.k; SG=SG)	=	18,00 N/mm²
γ_M =	1,30		

Calculation:

$A_{w,v}$ =	$2*b*t_v$	=	84,00 cm²
$A_{w,bo}$ =	$(d+1)*(h_H-2*t_v)$	=	26,40 cm²
A_w =	b_H*h_H-MAX($A_{w,bo}$;$A_{w,v}$)	=	168,00 cm²
$f_{t,0,d}$ =	$k_{mod} * f_{t,0,k} / \gamma_M$	=	11,08 N/mm²

Maximum force to be accepted by the construction:

$F_{t,d,max}$ =	$f_{t,0,d}*A_w*0,1$	=	186,14 kN